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A R M S T R O N G L A B O R A T O R Y

COMPLIANCE WITH CALIFORNIA RULE 480, CHROME PLATING FACILITY, BUILDING 243G, McCLELLAN AIR FORCE BASE, CALIFORNIA

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December 1991

Final Technical Report for Period 24-31 July 1991

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AIR FORCE SYSTEMS COMMAND
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13. ABSTRACT *(Maximum 200 words)*

California Rule 480, adopted in Aug 89, specifies emissions standards for hexavalent chromium based on annual hexavalent chromium emissions and requires facilities to conduct compliance testing every 2 years. Compliance testing by personnel from the Armstrong Laboratory was conducted on the chrome plating facility, Bldg 243G at McClellan AFB. Two of the 3 scrubbers were tested using CARB Method 425 for total and hexavalent chrome. Results indicate the facility produces less than 2 lb (0.9 kg) per year of hexavalent chromium and is in compliance with rule 480 with an emission of equal to or less than .0034 mg/amp-h. Recommendations are made as to required biennial compliance testing.

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INTRODUCTION

Background

On 24-31 Jul 91, source emission testing for total and hexavalent chromium emissions was conducted on the scrubber exhaust system of the chrome plating facility located in Bldg 243G, McClellan AFB, CA. Two representative stacks were tested. Testing was performed by the Air Quality Function of Armstrong Laboratory. This survey was requested by the Director, Environmental Management, Sacramento Air Logistic Command (SM-ALC/EM) to demonstrate compliance with California's Rule 480. Personnel involved with on-site testing are listed in Appendix A.

Site Description

Three vertical packed bed scrubbers are installed in the exhaust system of the chrome plating facility in Bldg 243G. The scrubbers provide emission control for chromium particulates which are exhausted from 9 chrome plating tanks in the form of chromic acid mist. The scrubbers are positioned in a line with scrubber No. 1 (Fig. 1) being the most distant from Bldg 243G.

The scrubbers used in this system are manufactured by Viron International. Each scrubber is made up of the scrubber housing, containing the packing material and mist eliminator packing, and two 62-in. (155-cm) vertical exhaust stacks each housing a 30,000-cubic feet per minute (cfm) inline centrifugal fan. Figure 2 provides a diagrammatic view of the typical scrubber. The packing material, which is continually wetted by recirculating water, captures the mist particulates in the exhaust gas as the gas stream flows in a circuitous path through the bed. The mist eliminator packing is a series of static baffles placed across the mist-laden gas stream which acts as an impingement-type separator to capture liquid droplets entrained in the existing gas.

Applicable Standards and Guidelines

Rule 480, adopted in 1988, requires chrome plating facilities to have source emission testing every 2 years to demonstrate compliance with various provisions of the rule. The rule aims to control hexavalent chromium emissions, a heavy metal pollutant with a TLV-TWA of 0.05 mg/m^3 and a confirmed human carcinogen. The rule categorizes hard plating shops as small, medium or large. These categories would have to achieve an emission reduction of 95, 95 to 99, or 99 to 99.8 percent respectively or emit hexavalent chromium at a rate less than 0.15, 0.03, or 0.006 mg per amp-h. Rule 480 can be found in Appendix B.

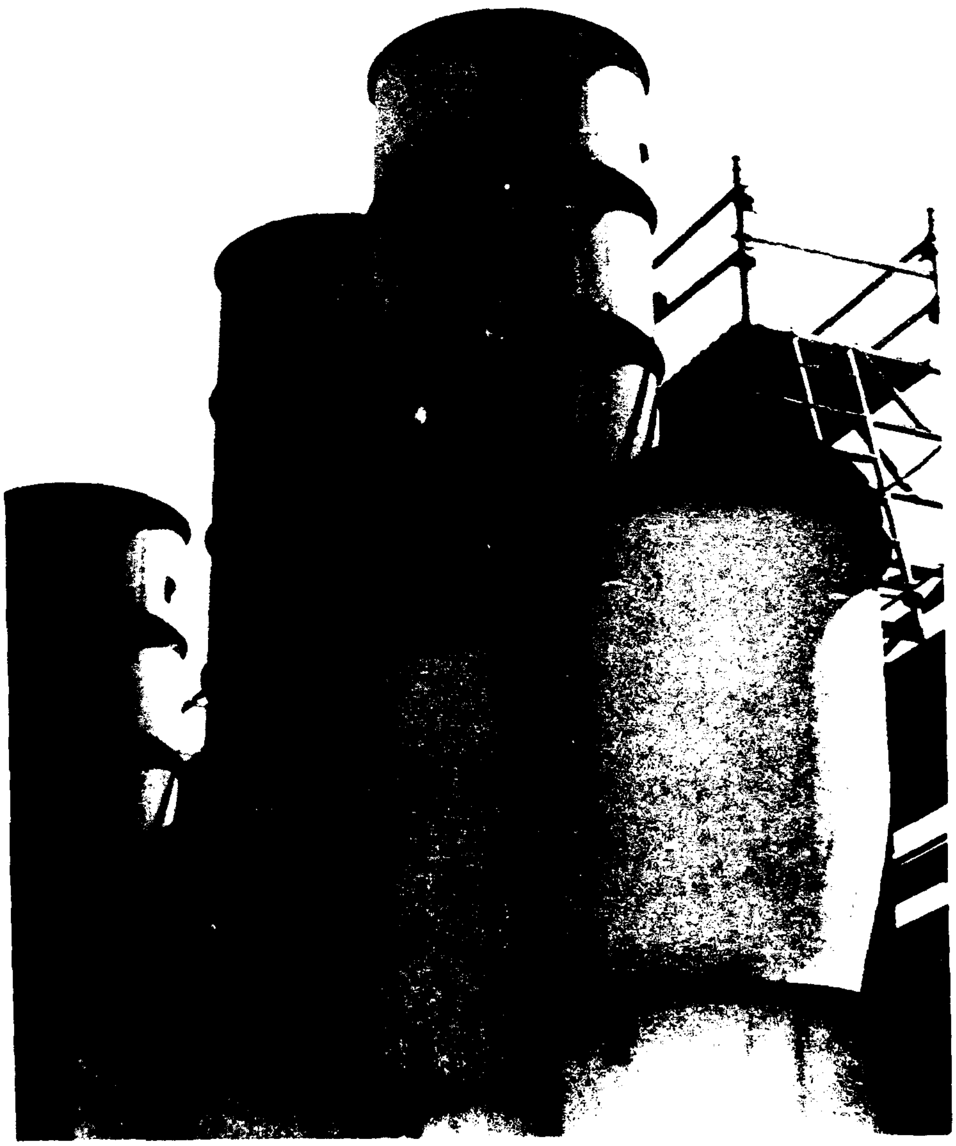

Figure 1. View of stacks with stack No. 1 in foreground.

METHODS AND MATERIALS

Sampling and analysis methodology used during this project are found in California Air Resources Board (CARB) Test Method 425 as amended in September 1990, "Determination of Total Chromium and Hexavalent Chromium Emissions from Stationary Sources" (Appendix C). Options chosen in Method 425 include using new precleaned and tested glassware for each test run. Also, because low values of hexavalent chromium were expected, each sample run was 240 min and impingers were not combined, but split and analyzed per the method. Hexavalent chromium is analyzed via the phenylcarbazide method and total chromium is analyzed via atomic absorption.

Emission testing is accomplished on 2 representative stacks of different scrubbers. These stacks have been denoted as stack 1 (scrubber 1) and stack 2 (scrubber 2). These procedures were coordinated with the Sacramento County Air Pollution Control District.

Extensions have been added to each stack tested to ensure that the minimum requirements for sampling locations with regards to CARB Method 1 are met. The extensions allowed placement of the sampling ports two duct diameters downstream from the exhaust fan and one-half duct diameter upstream from the stack exit. The inside stack diameter at the sampling port location for each stack is 62 in. (155 cm). Based on the duct diameter, port location and type of sampling required (particulate), a total of 24 traverse points were determined for source emission evaluation, (1, 4). The total time for each sampling run was 240 min with sampling time for each traverse point at 10 min.

Samples are collected using the sampling train of CARB Method 425. The train consisted of a button-hook glass probe nozzle, heated probe with glass liner, impingers, a Teflon filter in a glass filter holder and pumping and metering device. Flue gas velocity pressure is measured at the nozzle tip using a Type-S pitot tube connected to a Dwyer 10-in. inclined-vertical manometer. Type K thermocouples were used to measure flue gas as well as sampling train temperatures. Calibration data are presented in Appendix H (2).

Many of the emission calculations are done using "Source Testing Calculation and Check Programs for Hewlett-Packard 41 Calculators" developed by the Environmental Protection Agency's Office of Air Quality Planning and Standards, Research Triangle Park NC (3).

RESULTS AND DISCUSSION

Field Results

Scrubbers were tested during maximum output plating operations. Metal plates were used as material being plated to maintain a maximum output. Individual tanks current was set appropriate for actual plating work. The number of plating tanks in operation during testing ranged from 7 to 9. Average total plating current was around 18,000 amp-h (Appendix D).

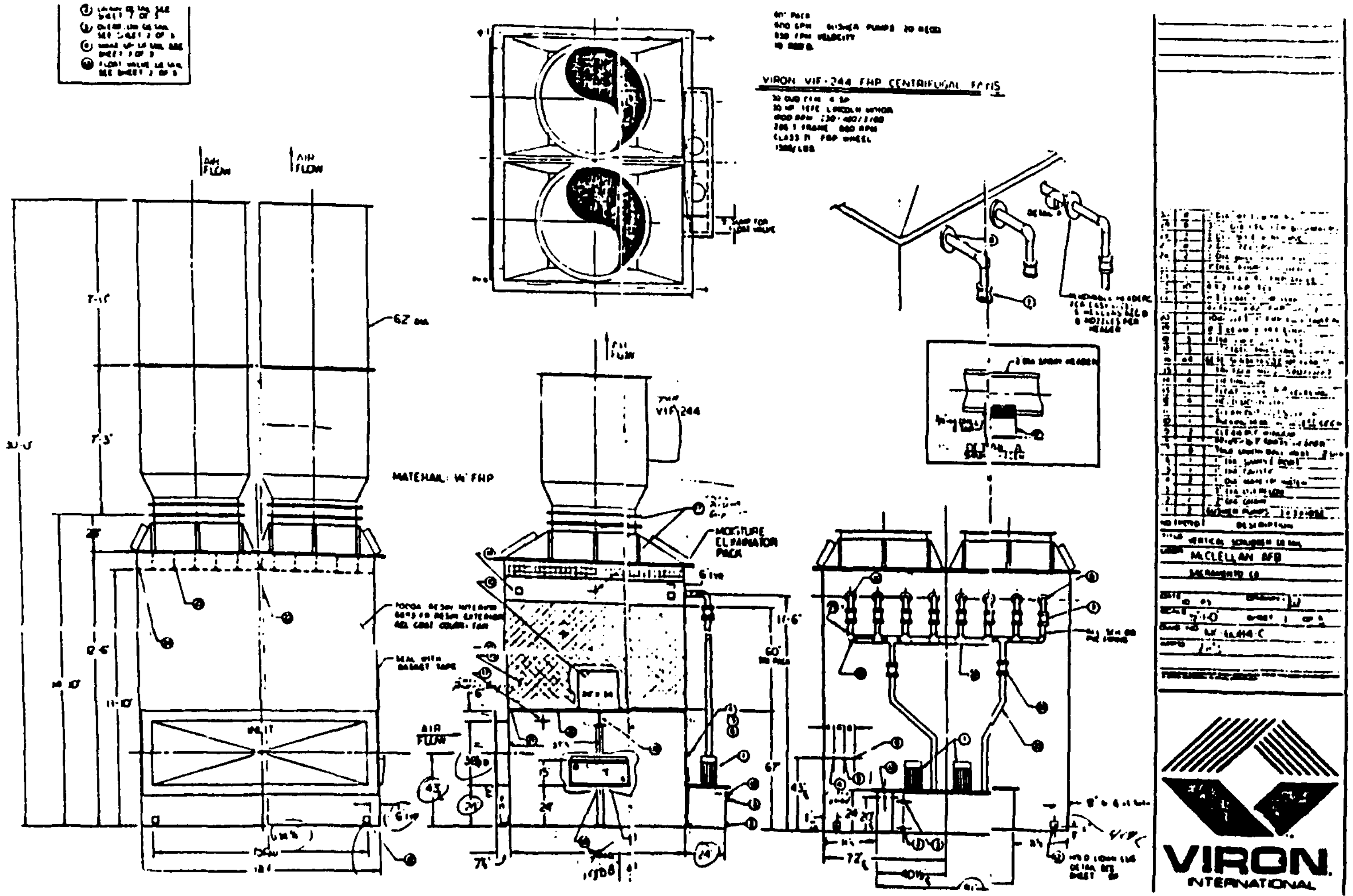

Figure 2. Diagrammatic view of typical scrubber.

Emission testing started with stack 2 on 24 Jul 91. Preliminary velocity, cyclonicity, and leak checks were all nominal; however, port locations were 26.5 in. (66.25 cm) upstream instead of the 31 in. (77.5 cm) as required by EPA and CARB Method 1. Emission testing on stack 2 concluded with run 3 on 26 Jul 91. Emission testing continued with stack 1 on 29 Jul 91. Port locations were similarly placed on stack 1 as on stack 2. Because of inadequate scaffolding, a man lift had to be brought in to support equipment and personnel. The man lift proved inadequate, and it was determined that safety requirements were not being adequately met. At the conclusion of run 1 on stack 1, port locations were changed to accommodate personnel safety. This change also brought port locations within the 2 duct and one-half duct diameter criteria of EPA (1) and CARB Method 1 (4). However, a check of cyclonicity showed the flow to be unacceptable. Straightening vanes were dropped in the stack to correct the flow. The cyclonicity was measured as 12.5°. This measurement is acceptable to EPA methods, but not acceptable according to California methods. Testing (runs 2 and 3) continued at the new ports of stack 1. Isokinetics were good for all runs. The district chose to see the data before making a decision as to its acceptability. Field data and calculations are in Appendix E for stack 1 and Appendix F for stack 2.

A total of 25 samples were collected (i.e, 12 samples per stack and 1 sodium hydroxide (NaOH) blank). Each run represented 4 samples: a precheck wash of the probe with 0.1 N NaOH, a probe wash, impinger 1, and impinger 2. Filters were placed in impinger 1. All samples were received at our office and in good condition on 5 Aug 91. The samples were subsequently submitted for analysis to the Armstrong Laboratory, Occupational and Environmental Health Directorate, Analytical Services Division.

Analysis Results

The analyses were completed on 13 Aug 91. A summary of the laboratory results is found in Table 1. The laboratory report is in Appendix G. All hexavalent chromium samples were below the detection limit of 0.02 μg/ml. This detection limit was achieved with a 1.0-cm cell using the phenylcarbazide method. Total chromium was twice detected in the first impinger and also in the probe wash of run 3 of stack 1. Since hexavalent chromium was below detection limits, its detection limit is used as the worst case to determine a collected mass of hexavalent chromium. Algorithms used to determine the worst case hexavalent chromium are listed at the bottom of Table 1. Mass values range from 5.12 μg to 5.9 μg. These values are incorporated in Table 2 to obtain stack emission rates. Average emission rates for stack 1 and 2 are .0034 and .0029 mg/amp-h, respectively.

Finally the stack emission rates are multiplied by the total number of stacks to determine the chrome plating facilities "worst case" hexavalent chromium emissions (Table 3). Using either stack 1 or stack 2 data gives facility emission rates of .0204 and .0174 mg/amp-h, respectively. This is less than the category 1 standard of .15 mg/amp-h and also less than the category 2 standard of .03 mg/amp-h. With the facilities "worst case" annual emissions of .353 lb/year (0.1589 kg/yr) (Table 3), this data places

TABLE 1. SUMMARY OF LABORATORY RESULTS

Date	Stack #	Run/Sample #	Sample Results (µg/ml)[1] CR+6	Sample Results (µg/ml)[1] Total CR	Sample Volume (ml)		Cr+6 Mass[2] (µg)
24 Jul	2	1/probe	<.02	<.050	108		2.16
		1/imp1	<.02	.081	120		2.40
		1/imp2	<.02	<.050	108		.96
						Total	5.52
25 Jul	2	2/probe	<.02	<.050	100		2.00
		2/imp1	<.02	<.050	117.5		2.35
		2/imp2	<.02	<.050	106		.81
						Total	5.16
26 Jul	2	3/probe	<.02	<.050	109		2.18
		3/imp1	<.02	<.050	120		2.40
		3/imp2	<.02	<.050	108		.96
						Total	5.54
29 Jul	1	1/probe	<.02	<.050	140		2.80
		1/imp1	<.02	<.050	123		2.46
		1/imp2	<.02	<.050	106		.64
						Total	5.90
30 Jul	1	2/probe	<.02	<.050	130		2.60
		2/imp1	<.02	<.050	133		2.66
		2/imp2	<.02	<.050	103		.24
						Total	5.50
31 Jul	1	3/probe	<.02	.052	112		2.24
		3/imp1	<.02	.070	122		2.44
		3/imp2	<.02	<.050	104		.44
						Total	5.12

[1] < indicates none detected and the appropriate detection limit

[2] The Cr^{+6} mass of the probe and impinger 1 is computed as the measured Cr^{+6} concentration multiplied by the sample volume. If the measured Cr^{+6} concentration is below detection limits, then the Cr^{+6} mass of the probe and impinger 1 is computed as the detection limit multiplied by the respective sample volume to represent a worst case.

When Impinger 2 is below detection limits, its Cr^{+6} mass is computed as the ratio of collected moisture of impinger 1 and impinger 2 multiplied by the computed mass of impinger 1 [i.e., (volume sample of impinger 2 - 100 ml)/(sample volume of impinger 1 - 100 ml) x impinger 1 Cr^{+6} mass]. This volume also represents a worst case.

TABLE 2. SUMMARY OF EMISSION DATA

DATE	Stack #	Run #	Avg Rate of Current I (amp-h/h)	Std Meter Volume V_m (Std ft^3)	Stack Flow Rate R_s (Std ft^3/min)	Cr+6 Mass[1] M (μg)	Emission Rate[2] E_r (mg/amp-h)	Emission Rate[2] E_{re} (lb/h)
24 Jul	2	1	18,212.5	115.377	18,251	5.52	.0029	1.155E-4
25 Jul	2	2	18,131.5	121.498	19,479	5.16	.0027	1.094E-4
26 Jul	2	3	17,765.0	127.380	17,765	5.54	.0029	1.154E-4
						Avg	.0029	1.134E-4
29 Jul	1	1	18,560.0	108.215	17,255	5.90	.0030	1.245E-4
30 Jul	1	2	18,725.0	123.236	19,658	5.50	.0028	1.160E-4
31 Jul	1	3	11,524.0	118.632	19,050	5.12	.0043	1.088E-4
						Avg	.0034	1.166E-4

[1] Cr^{+6} Mass is taken from Table 1 and represents a worst case using the detection limit

[2] $E_r = .06(M \times R_s)/(V_m \times I)$ The sampling time of 4 h and the μg to mg conversion are part of the constant

$E_{re} = 1.3216E{-7}(M \times R_s)/V_m$ The sampling time of 4 h and the μg to lb conversion are part of the constant

TABLE 3. FACILITY Cr+6 EMISSIONS

Stack #	Facility Emission Rate[1] (mg/amp-h)	Facility Emission Rate[1] (lb/h)	Annual Avg Current[2] (kamp-h/yr)	Annual Facility[3] Emissions (lb/yr)	Rule 480 Category (Applicablity/Standard)
2	.0174	6.750E-4	7845.0	0.301	para 302.1/0.03 mg/amp-h
1	.0204	6.948E-4	7845.0	0.353	para 302.1/0.15 mg/amp-h

[1] The facility emission rate is determined by multiplying E_r or E_{re} by the number of stacks (i.e., 6).

[2] The annual average current is determined from data in Appendix D.

[3] The Annual Facility Cr^{+6} emissions are determined from multiplying the Facility Emission Rate (FER)(mg/amp-h) by the annual average current (AAC)(kamp-h/yr) (i.e., (FER)(1,000 x AAC)/4.54E+5).

the chrome plating facility in category 1 of Rule 480 (para 302.1) (i.e., annual emissions are less than 2.0 lb of hexavalent chromium). Consequently, the chrome plating facility is in compliance with category 1 of Rule 480.

CONCLUSIONS

The Chrome Plating Facility, Bldg 243G at McClellan AFB produces less than 2 lb/year (0.9 kg/year) of hexavalent chromium emissions and is placed in category 1 of California Rule 480 for compliance purposes. The facility's emission rate of .0204 mg/amp-h is less than the .15 mg/amp-h standard of category 1 and is, therefore, in compliance with Rule 480.

RECOMMENDATIONS

Rule 480 requires testing the chromium packed bed scrubber stacks for hexavalent chromium emissions every 2 years. Though the chrome plating facility is in compliance with Rule 480, certain items require attention either on a regular basis or before future compliance surveys. These requirements include the following:

1. Ensure operators and supervisors are aware of compliance issues and the full impact of noncompliance.

2. Continue to document operating data as accurately as possible.

3. Negotiate with the district to choose a single representative stack for future source emission surveys.

4. Ensure adequate scaffolding extending out (normal to the stack) 6.0 ft (182.9 cm) and 10.0 ft (304.8 cm) either side (tangentially) of the chosen representative stack.

5. Install (weld) a permanent straightening vane (a tic-tac-toe configuration) which is at least 6.0 ft (182.9 cm) deep and located above the fan.

6. Install and locate sampling ports 90° apart in the same horizontal plane, at least 10.5 ft (320.0 cm) downstream of the top of the straightening vane and 31.0 in. (78.7 cm) or more upstream of the stack top.

REFERENCES

1. Code of Federal Regulations, Title 40, Protection of Environment, Part 60, Standards of Performance for New Stationary Sources, July 1, 1987.

2. Quality Assurance Handbook for Air Pollution Measurement Systems - Volume III, Stationary Source Specific Methods, U.S. Environmental Protection Agency, EPA-600/4-77-027-b, Research Triangle Park, North Carolina, December 1984.

3. Source Test Calculation and Check Programs for Hewlett-Packard 41 Calculators. U.S. Environmental Protection Agency, EPA-304/1-85-018, Research Triangle Park, North Carolina, May 1987.

4. Stationary Source Test Methods - Volume I and III, California Air Resources Board, Sacramento, California.

APPENDIX A

Personnel Information

PERSONNEL INFORMATION

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   Capt Ronald V. Vaughn
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   Ms Jeannie Moore, SM-ALC/EMC
   Mr Dan Durfee, SM-ALC/EMR
   Mr Jerry Stiles, SM-ALC/EMR

APPENDIX B

California Rule 480

RULE 480 CHROME PLATING AND CHROMIC ACID ANODIZING

(Adopted 8-22-89)

INDEX

100 **GENERAL**

101 **PURPOSE:** To limit the emission of hexavalent chromium to the atmosphere from chrome plating and chromic acid anodizing operations.

200 **DEFINITIONS:** For the purposes of this rule the following definitions shall apply:

201 **AMPERE-HOURS:** The integral of electrical current (amperes) applied to a plating tank over a period of time (hours).

202 **ANTI-MIST ADDITIVE:** A chemical which reduces the emission rate from the tank when added to and maintained in the plating tank.

203 **CHROME:** Metallic chrome.

204 **CHROME PLATING:** Hard or decorative chrome plating.

205 **CHROMIC ACID:** An aqueous solution of chromium trioxide (CrO_3) or a commercial solution containing chromium trioxide, chromic acid (H_2CrO_4), dichromic acid ($H_2Cr_2O_7$) or trichromic acid ($H_2Cr_3O_{10}$).

206 **CHROMIC ACID ANODIZING:** The electrolytic process by which a metal surface is converted to an oxide surface coating by the action of a solution containing chromic acid.

207 **CHROMIUM:** Hexavalent chromium, which refers to the valence state of +6 for the chromium in the aqueous solution.

208 **CONTROL EQUIPMENT:** Any device which reduces chromium air contaminant emissions from an emissions collection system and which has been approved by the Air Pollution Control Officer.

209 **DECORATIVE CHROME PLATING:** The process by which chromium is electrodeposited from a solution containing compounds of chromium onto an object resulting in a chrome layer 1 micron (0.04 mil) thick or less.

210 **EMISSION FACTOR:** The mass of chromium emitted during a test conducted in the emissions collection system in accordance with ARB Test Method 425, divided by the ampere-hours consumed by the tanks in the tested emissions collection system, expressed as the mass of chromium emitted per ampere-hour of electrical current consumed.

211 **EMISSIONS COLLECTION SYSTEM:** A device or apparatus used to gather chromium emissions from the surface of a chrome plating or chromic acid anodizing tank or tanks.

212 **FACILITY-WIDE EMISSIONS FROM HARD CHROME PLATING OR CHROMIC ACID ANODIZING:** The total uncontrolled chromium emissions from all hard chrome plating or chromic acid anodizing at the stationary source over a calendar year. Emissions shall be calculated as the sum of emissions from the emissions collection system(s) at the stationary source. The emissions from each emission collection system shall be calculated by multiplying the emission factor for that emissions collection system by the sum of the ampere-hours consumed during that year for all of the tanks served by the emissions collection system.

213 **HARD CHROME PLATING:** The process by which chromium is electrodeposited from a solution containing compounds of chromium onto an object resulting in a chrome layer thicker than 1 micron (0.04 mil).

214 **PLATING TANK:** Any container used to hold a chromium or chromic acid solution for the purpose of chrome plating or chromic acid anodizing.

215 **SOURCE:** Any operation that produces and/or emits air pollutants.

216 **UNCONTROLLED CHROMIUM EMISSIONS:** The chromium emissions from the emissions collection systems at the stationary source calculated as if no control equipment is in use. For the purpose of determining compliance with this rule, the uncontrolled chromium emissions shall be calculated using an emission factor based on tests conducted in accordance with ARB Test Method 425 or 14 mg/ampere-hour, whichever is less.

300 STANDARDS

301 **DECORATIVE CHROME PLATING** - A person shall not operate a decorative chrome plating tank unless one of the following control measures is used in a manner which has been demonstrated to and approved by the Air Pollution Control Officer (APCO) as reducing chromium emissions by 95 percent or more relative to the uncontrolled chromium emissions.

301.1 An anti-mist additive is continuously maintained in the plating tank, or;

301.2 Control equipment is installed and used, or;

301.3 An equivalent method approved by the Air Pollution Control Officer is installed and used.

302 **HARD CHROME PLATING OR CHROMIC ACID ANODIZING:**

302.1 A person shall not operate a hard chrome plating tank or chromic acid anodizing tank unless the tank has an emissions collection system that meets one of the following requirements:

a. The chromium emissions from the emissions collection systems serving the plating tank are reduced by at least 95 percent from the uncontrolled chromium emissions, or;

b. The chromium emissions from the emissions collection systems serving the plating tank are reduced to less than 0.15 milligrams(mg) of chromium per ampere-hour of electrical charge applied to the plating tank.

302.2 A person shall not operate a hard chrome plating tank or chromic acid anodizing tank at a stationary source where the facility-wide chromium emissions from hard chrome plating or chromic acid anodizing are greater than 2 pounds per year, but less than 10 pounds per year, unless the tank has an emissions collection system that meets one of the following requirements:

a. The chromium emissions from the emissions collection systems serving the plating tank are reduced by at least 99 percent from the uncontrolled chromium emissions, or;

b. The chromium emissions from the emissions collection systems serving the plating tank are reduced to less than 0.03 mg of chromium per ampere-hour of electrical charge applied to the plating tank.

302.3 A person shall not operate a hard chrome plating tank or chromic acid anodizing tank at a stationary source where the facility-wide chromium emissions from hard chrome plating or chromic acid anodizing are greater than or equal to 10 pounds per year, unless the tank has an emissions collection system that meets one of the following requirements:

a. The chromium emissions from the emissions collection systems serving the plating tank are reduced by at least 99.8 percent from the uncontrolled chromium emissions, or;

b. The chromium emissions from the emissions collection systems serving the plating tank are reduced to less than 0.006 mg of chromium per ampere-hour electrical charge applied to the plating tank.

302.4 Compliance shall be verified by source testing every 24 months.

400 ADMINISTRATIVE REQUIREMENTS

401 RECORDKEEPING REQUIREMENTS: A person subject to the provisions of Section 300 of this rule shall meet the following applicable requirements:

401.1 A weekly record of anti-mist additive concentrations or any other measurements recommended by the manufacturer's specification and the Air Pollution Control Officer shall be maintained. Recordkeeping shall begin on the date of final compliance.

401.2 A weekly record of current integrated over time (ampere-hours) for all plating tanks used at a chrome plating or chromic acid anodizing stationary source shall be maintained. Recordkeeping shall begin on August 22, 1989.

401.3 All records including all pertinent information relative to the operation of the plating tanks, all source testing, and all information relative to the emissions collection system and the control equipment shall be maintained for two years and shall be made available to the Air Pollution Control Officer upon request.

402 COMPLIANCE SCHEDULES

402.1 A person subject to the provisions of Section 301 shall be in final compliance with the requirements of Section 301, and shall submit to the Air Pollution Control Officer an application for a Permit to Operate, no later than March 1, 1990.

402.2 A person subject to the provisions of Section 302, except a person subject to the provisions of Subsection 302.2 shall meet the following compliance schedule:
a. Submit to the Air Pollution Control Officer an application for a Permit to Operate the plating tank no later than March 1, 1990, and;
b. Submit to the Air Pollution Control Officer an application for Authority to Construct the equipment necessary to comply with the requirements of Subsection 302.1, if needed no later than September 1, 1990, and;
c. Achieve final compliance with the requirements of Subsection 302.1 no later than March 1, 1991.

402.3 A person subject to the provisions of Subsection 302.2 shall meet the following compliance schedule:
a. Submit to the Air Pollution Control Officer an application for a Permit to Operate the plating tank no later than March 1, 1990, and;
b. Submit to the Air Pollution Control Officer an application for Authority to Construct the equipment necessary to comply with the requirements of Subsection 302.2, if needed, no later than March 1, 1991, and;
c. Achieve final compliance with the requirements of Subsection 302.2 no later than September 1, 1991.

402.4 A person subject to the provisions of Subsection 302.3 shall, in addition, meet the following compliance schedule:
a. Submit to the Air Pollution Control Officer an application for a Permit to Operate the plating tank no later than March 1, 1990, and;
b. Submit to the Air Pollution Control Officer an application for Authority to Construct the equipment necessary to comply with the requirements of Subsection 302.3, if needed, no later than March 1, 1991, and;
c. Achieve final compliance with the requirements of Subsection 302.3, no later than September 1, 1993.

500 TEST METHODS

Compliance with the chromium emissions requirement in Section 302 of this rule shall be determined by ARB Test Method 425.

APPENDIX C

California Air Resources Board Sampling Method 425

State of California
Air Resources Board

Method 425

Determination of Total Chromium and Hexavalent Chromium Emissions from Stationary Sources

Adopted: January 22, 1987

Amended: September 12, 1990

METHOD 425
DETERMINATION OF TOTAL CHROMIUM AND HEXAVALENT CHROMIUM EMISSIONS FROM STATIONARY SOURCES

1 APPLICABILITY, PRINCIPLE, AND FIGURES

1. 1 APPLICABILITY

This method applies to the determination of hexavalent chromium (Cr(VI)) and total chromium emissions from stationary sources. Applicability has been demonstrated for the metal finishing and glass industries. Its applicability has not been demonstrated for sources with high particulate mass emission rates.

1. 2 PRINCIPLE

Particulate emissions are collected from the source in an alkaline medium by use of CARB Method 5, with modifications noted in this method. The components of the collected sample are each divided into two equal portions with one portion of each component used for total chromium analysis and the other portion used for hexavalent chromium analysis.

1. 2. 1 Hexavalent Chromium Analysis

For the hexavalent chromium analysis the collected sample component portions are extracted in an alkaline solution and analyzed by the diphenylcarbazide colorimetric method.

1. 2. 2 Total Chromium Analysis

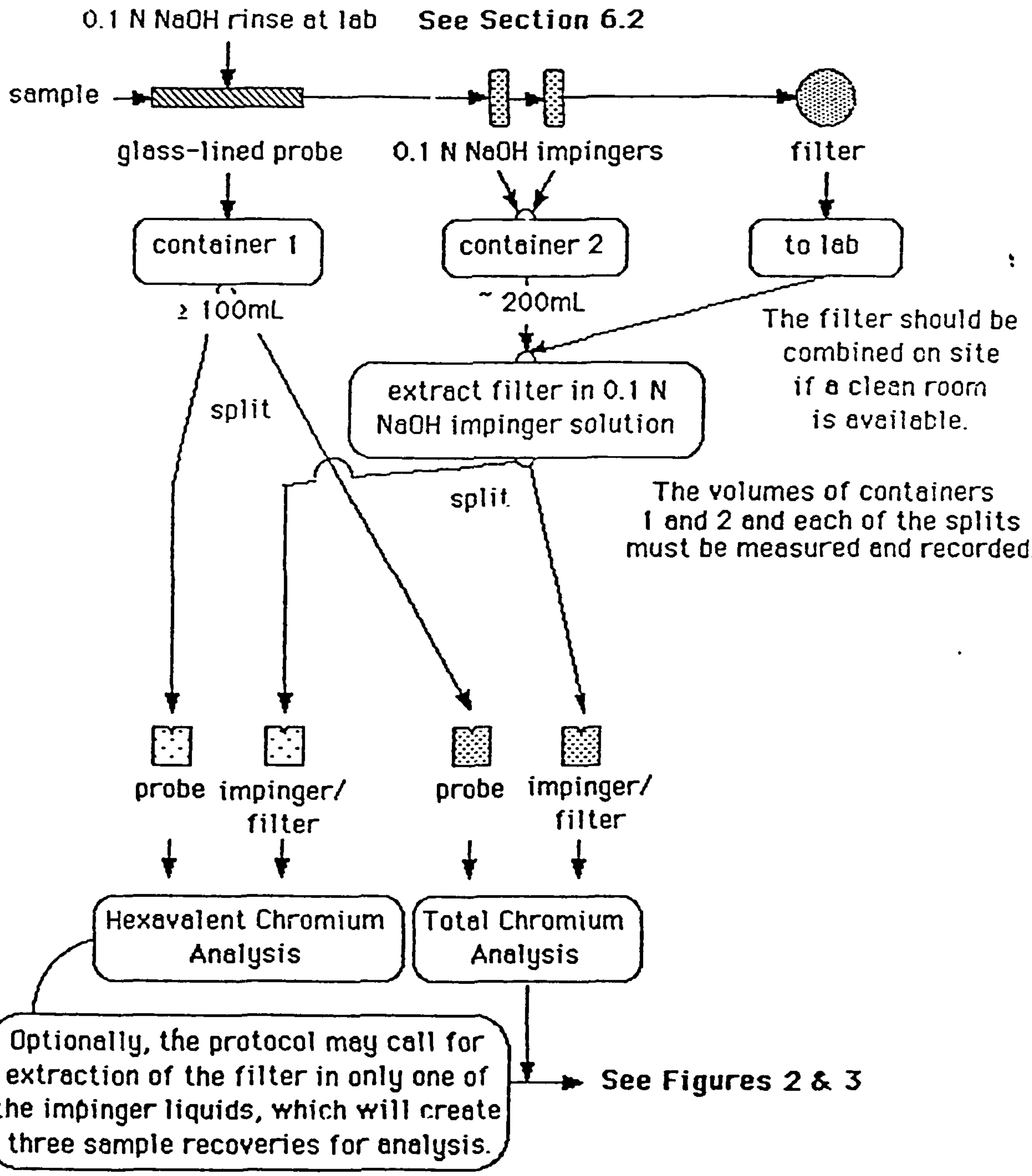
For the total chromium analysis the collected samples must be prepared in order to convert organic forms of chromium to inorganic forms, to minimize organic interferences, and to convert the sample to a suitable solution for analysis. Samples are then subjected to an acid digestion procedure. Following the appropriate dissolution and dilution of the sample, a representative aliquot is placed manually or by means of an automatic sampler into a graphite tube furnace. The sample aliquot is then slowly evaporated to dryness, charred (ashed), and atomized. The absorption of hollow cathode radiation during atomization will be proportional to the chromium concentration.

1. 3 FIGURES

The following figures summarize features of this method.

1. 3. 1 Figure 1.

Sample Collection and Recovery for Hexavalent and Total Chromium



1. 3. 2 Figure 2.

Hexavalent Chromium Analysis

916-324-8613

James Loop ARB

optionally, the protocol may call for extraction of the filter in only one of the impinger liquids, which will create three sample recoveries for analysis

See Figure 1 and Sections 6.4 and 6.5 →

typically:
two separate analyses

transfer ~ 35 mL to a 100mL beaker

adjust the pH to 1±0.2 with 6N sulfuric acid and add 1.0 mL of diphenylcarbazide solution

bring to volume in a 50 mL volumetric flask

dilute to volume with water - let color develop 10 minutes

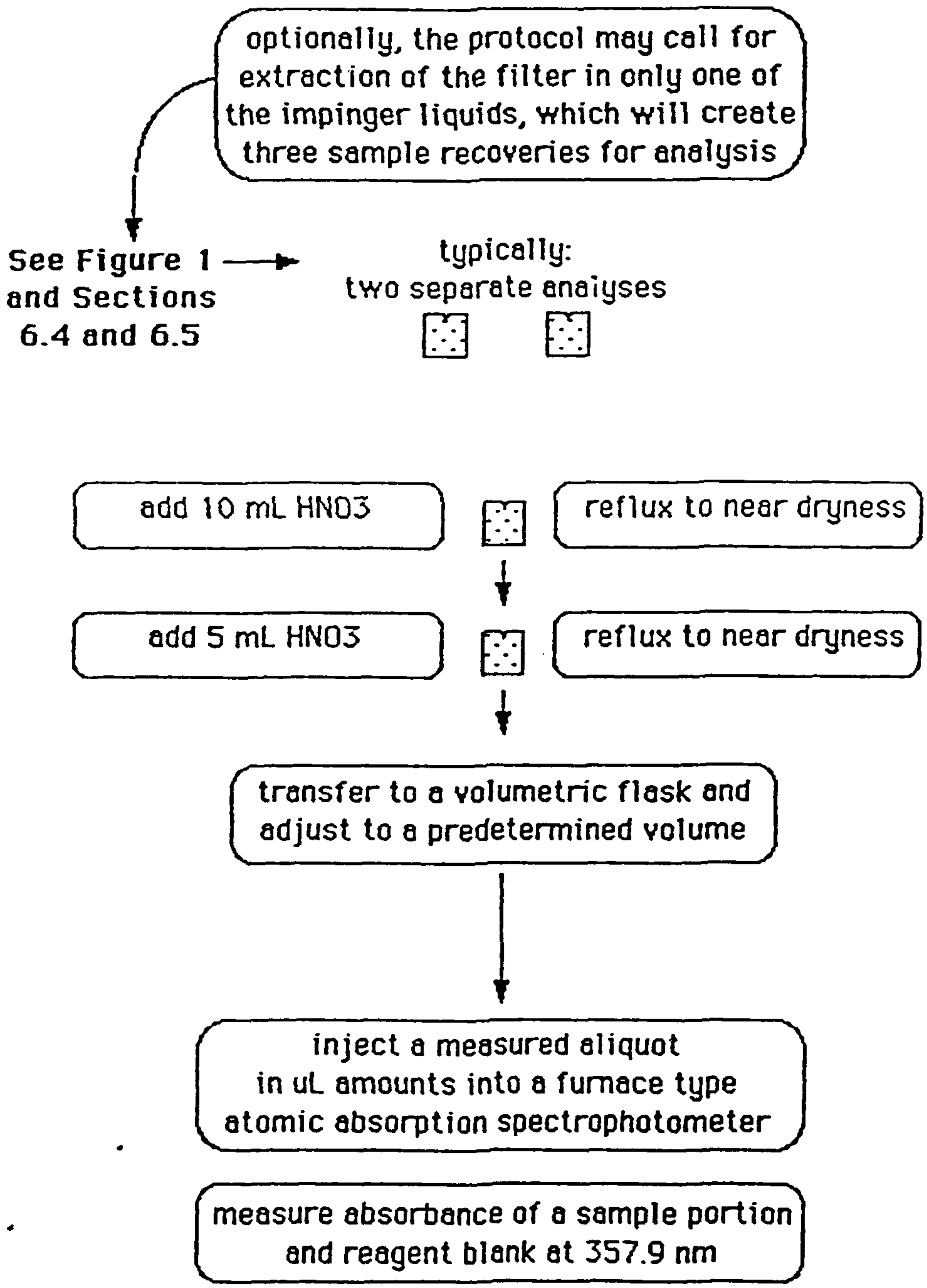
filter to remove suspended solids after pre-wetting medium retention filter paper with a few mL each of first reagent blank and then sample

measure absorbance of a sample portion and reagent blank at 540 nm

if reading exceeds calibration, dilute with reagent blank or remeasure using less of remaining sample

1. 3. 3 Figure 3.

Total Chromium Analysis



2 RANGE, SENSITIVITY, PRECISION, AND INTERFERENCES

2. 1 RANGE

2. 1. 1 Hexavalent Chromium

A straight line response curve was obtained in the range 0.5 ug Cr(VI)/50 mL to 3.0 ug Cr(VI)/50 mL. For a minimum analytical accuracy of 100 ± 10 percent, the lower limit of the range is 2 ug/100mL. The upper limit can be extended by appropriate dilution or by using a smaller cell path length after recalibration for the smaller cell. (Reference 8.3)

2. 2 SENSITIVITY

The minimum sampling volume should be calculated for each test and should be based upon [1] the targeted minimum detectable concentration at the source, [2] the expected minimum detection limit achievable at the laboratory, and [3] the sampling time limitations at the source.

2. 2. 1 Hexavalent Chromium

A minimum detection limit, of 0.2 ug Cr(VI)/50mL using a 5 cm cell, has been observed. (Reference 8.3)

2. 3 PRECISION FOR HEXAVALENT CHROMIUM

The overall precision for sample collection and analysis for Cr(VI) will be determined after data are collected from a test protocol which includes multiple simultaneous sampling techniques.

2. 4 INTERFERENCES

2. 4. 1 Interferences of Hexavalent Chromium

Molybdenum, mercury and vanadium react with diphenylcarbazide to form a color; however, approximately 20 mg of elements can be present in a sample without creating a problem. Iron produces a yellow color, but this effect is not measured photometrically at 540 nm.

2. 4. 2 Interferences for Total Chromium

2. 4. 2. 1 The long residence time and high concentrations of the atomized sample in the optical path of the graphite furnace can result in severe physical and chemical interferences. Furnace parameters must be optimized to minimize these effects. If the analyte is not completely volatilized and removed from the furnace during atomization, memory effects will occur. If this situation is detected, the tube should be cleaned by operating the furnace at higher atomization temperatures.

2.4.2.2 Nitrogen should not be used as the purge gas because of a possible CN band interference.

2.4.2.3 Low concentrations of calcium may cause interferences; at concentrations above 200 mg/L calcium's effect is constant. Calcium nitrate is therefore added to ensure a known constant effect. This step may be omitted if the sample is known to be free of calcium or no analytical interferences are expected.

2.5 ALTERNATIVE METHODS

Direct Measurement of Gas Volumes through Pipes and Small Ducts

Air Resources Board Method 2A may be used, where applicable, as an alternative to pitot tube methods specified in Method 5, as referenced herein.

Hexavalent Chromium Determination by Ion Chromatography

For hexavalent chromium concentrations which are within the detection range of ion chromatography, this analytical method may be used instead of the colorimetry method specified in these pages. This option applies only to the analysis of hexavalent chromium. The remainder of the test method shall be performed as specified.

Total Chromium Determination by Flame Atomic Absorption Spectroscopy

For high total chromium concentrations which are within the detection range of flame atomic absorption spectroscopy, this analytical method may be used instead of the furnace type method specified in these pages. This option applies only to the analysis of total chromium. The remainder of the test method shall be performed as specified.

Other Methods

The Executive Officer or authorized representative may approve an alternative test method (including other techniques or conditions) for the determination of hexavalent and/or total chromium emissions from stationary sources. To approve an alternative method, the Executive Officer or authorized representative may require the submission of test data demonstrating that the alternative method is equivalent to Method 425.

3 APPARATUS

All surfaces which may come in contact with sample must be glass, Teflon, or other similarly non-metallic (stainless steel may be a source of chromium contamination) inert material. See Section 5.2.

Any other sampling apparatus which, after review by the Executive Officer, is deemed equivalent for the purposes of this test method, may be used.

3. 1 SAMPLING TRAIN

Except where otherwise noted in this method, same as CARB Method 5, Section 2.1. Exceptions include a glass nozzle, a glass lined stainless steel probe, 0.1 N NaOH in the first two impingers, a Teflon-coated glass fiber filter, and a silica gel moisture trap after the filter. As shown in Figure 1, sample flow should be through the probe first, then the impingers, and then the filter.

3. 2 SAMPLE RECOVERY

Except where otherwise noted in this method, same as CARB Method 5, Section 2.2. Also, see Section 6. 2 of this method.

3. 3 ANALYSIS

The following apparatus and materials are needed:

3. 3. 1 Analysis of Hexavalent Chromium

3. 3. 1. 1 100 mL beakers

3. 3. 1. 2 Filtration Apparatus

Vacuum unit constructed of glass, to accommodate sintered glass funnels. Medium porosity filter paper is optional. Wherever filtering is specified, centrifuging may also be performed at the analyst's option.

3. 3. 1. 3 Volumetric Flasks

100-mL and other appropriate volumes.

3. 3. 1. 4 Hot Plate

3. 3. 1. 5 Pipettes

Assorted sizes, as needed.

3. 3. 1. 6 Spectrophotometer

To measure absorbance at 540nm.

3. 3. 2 Analysis of Total Chromium

3.3.2.1 Philips Beakers

Borosilicate, 125mL, with digestion covers.

3.3.2.2 Chromium Hollow Cathode Lamp or Electrodeless Discharge Lamp.

3.3.2.3 Graphite Furnace

Any graphite furnace device with the appropriate temperature and timing controls.

3.3.2.4 Strip Chart Recorder

A recorder is recommended for furnace work so that there will be a permanent record and so that any problems with the analysis such as drift, incomplete atomization, losses during charring, changes in sensitivity, etc., can easily be recognized.

4 REAGENTS

Unless otherwise indicated, all reagents must conform to the specifications established by the Committee on Analytical Reagents of the American Chemical Society. Where such specifications are not available, use the best available grade.

4.1 SAMPLING

Except where otherwise noted in this method, same as CARB method 5, Section 3.1, except Teflon-coated glass fiber filters are used, and 0.1 N NaOH is used in the first two impingers. See section 4.3.2 below.

4.2 SAMPLE RECOVERY

Except where otherwise noted in this method, same as CARB Method 5, Section 3.2.

4.3 REAGENTS FOR HEXAVALENT CHROMIUM

4.3.1 Type II Water

Type II water is deionized and distilled, meeting American Society for Testing and Materials (ASTM) specification for type reagent - ASTM Test Method D 1193-77. The water should be monitored for impurities.

4.3.2 Batch of 0.1% NaOH Solution, Analytical Reagent Grade

The same batch of 0.1N NaOH solution should be used for impinger sampling, sample recovery, preparation, extraction, and analysis. Therefore, sampling and analytical personnel should coordinate their plans so that all steps in sampling and analysis use the same batch of solution which will be prepared fresh for each source test. Typically, dissolve 4.0 g NaOH in water in a 1 liter volumetric flask and dilute to the mark. Repeat, as necessary, so that a single batch of sufficient volume is prepared to serve all of the needs of sampling and analysis. Store the solution in a tightly capped polyethylene bottle.

4.3.3 Potassium Dichromate Stock Solution

Dissolve 2.829 g of analytical reagent grade potassium dichromate ($K_2Cr_2O_7$) in water, and dilute to 1 liter (1 mL = 1000 ug Cr(VI)).

4.3.4 Potassium Dichromate Standard Solution

Dilute 10.00 mL potassium dichromate stock solution to 100 mL (1 mL = 100 ug Cr(VI) with water.

4.3.5 Sulfuric Acid, 6N, Analytical Reagent Grade

Dilute 166 mL sulfuric acid to 1000 mL in water.

4.3.6 Diphenylcarbazide Solution, Analytical Reagent Grade

Dissolve 0.5 g of 1,5-diphenylcarbazide in 100 mL acetone. Store in a brown bottle. Discard when the solution becomes discolored.

4.3.7 0.1% Potassium Permanganate Solution

Analytical Reagent Grade

4.3.8 0.01% Potassium Permanganate Solution

Analytical Reagent Grade

4.3.9 Removal of Reducing Agents in the Reagents

The 0.1 N NaOH extraction solution (4.3.2) and the 6N sulfuric acid solution (4.3.5) may contain small amounts of reducing agents that can react with the hexavalent chromium. Potassium permanganate is added to these reagents in order to neutralize these reducing agents. Pipette 3 mL of the extraction solution into cuvettes A and B. Use cuvette A as a sample cell and cuvette B as a reference cell. Zero the instrument at 528 nm with both cuvettes. Wait 10 minutes. Add an adequate amount (uL) of 0.01% potassium permanganate solution (4.3.8) to cuvette A. Enough should be added so that after 10 minutes a slight change in absorbance is observed. This step may have to be repeated a number of times in order to determine the required amount of potassium permangante that is required. From the change in absorbance, calculate the amount of potassium permanganate that is needed to nuetralize the reducing agents found in the reagents. Then pipette the proper volume of higher concentration 0.1% potassium permanganate solution (4.3.7) into the reagents. This is done by assuming that the number of milliequivalents of reducing agents in the reagents are equal to the number of milliequivalents of 0.1% potassium permanganate pipetted.

This procedure is repeated with the 6N sulfuric acid solution.

4. 4 REAGENTS FOR TOTAL CHROMIUM

4. 4. 1 ASTM Type II Water (ASTM D1193)

Refer to section 4.3.1.

4. 4. 2 Concentrated Nitric Acid

4. 4. 2. 1 Reagent preparation should use Ultrex or equivalent grade HNO_3.

4. 4. 2. 2 Glassware cleaning should use ACS reagent grade HNO_3.

4. 4. 3 Hydrogen Peroxide (30%) (Optional), Analytical Reagent Grade

4. 4. 4 Matrix Modifier

Follow manufacturer's recommendations, when interferences are suspected.

4. 4. 5 Total Chromium Standard Stock Solution (1000mg/L)

Either procure a certified aqueous standard from a supplier (Spex Industries, Alpha Products, or Fisher Scientific) and verify by comparison with a second standard, or dissolve 2.829 g of Potassium Dichromate ($K_2Cr_2O_7$, analytical reagent grade) in Type II water and dilute to 1 liter.

4. 4. 6 Total Chromium Working Standards

All total chromium preparations injected for analysis shall be prepared to contain 1.0% (v/v) HNO_3. The zero standard shall be 1.0 % (v/v) HNO_3.

5 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

5. 1 SAMPLE COLLECTION

Except where otherwise indicated in this method, all samples are collected from the source by use of CARB Method 5. Exceptions include a glass nozzle, a glass lined stainless steel probe, 0.1 N NaOH in the first two impingers, and a Teflon-coated glass fiber filter. As shown in Figure 1, sample flow should be through the probe first, then the impingers, and then the filter.

5. 2 SAMPLE HANDLING AND PRESERVATION

All surfaces which may come in contact with sample must be glass, Teflon, or other similarly non-metallic (even stainless steel may be a source of chromium contamination) inert material and must be prewashed with detergents, soaked in 1:1 HNO_3 for several hours, rinsed with Type II water, and finally rinsed with 0.1 N NaOH batch solution. For awkward objects, such as long glass probes, soaking may be replaced by careful wiping.

5. 2. 1 Probes are generally the most difficult sampling apparatus to clean. Therefore, before use in sampling, to ensure that sampling equipment is clean and free of chromium contamination, apparatus which may come in contact with sample must be cleaned until a sample of final rinse for each probe has been analyzed as below the detection limit for total chromium. The procedures of Section 6 shall be followed for this contamination check.

If the specified glass probes are in short supply, the cleaning protocol required above could double the number of days necessary to complete a series of tests. Two options exist which reduce mid-course delays in a sampling effort:

5. 2. 1. 1 Another cleaning procedure may be used if it is tested and documented as achieving the objective of no detectable chromium in the last probe cleaning rinse. Testing and documentation shall include: a pre-test visit to the intended site, collection of samples from an intended test point with the highest expected concentration of chromium, trials of other cleaning procedures, and documentation of those which pass the analytical tests and are used instead of the cleaning procedures in Section 5.2.1 above.

5. 2. 1. 2 The risk of mid-course cleaning delays may be reduced by the use of a sufficient number of probes which have been pre-cleaned and contamination checked by the procedures of Sections 5.2.1 or 5.2.1.1. Extra probes should be included to allow for breakage.

6 PROCEDURES FOR SAMPLE RECOVERY, PREPARATION, AND ANALYSIS

6. 1 SILICA GEL WEIGHING

For stack gas moisture determination, weigh the spent silica gel or silica gel plus impinger to the nearest 0.5 g using a balance. This step may be conducted in the field.

6. 2 SAMPLE COLLECTION AND RECOVERY

The sample is collected using probe, impingers, and filter.

6. 2. 1 Probe

The probe is rinsed with 0.1 N NaOH. The total rinse volume should exceed 100 mL and be stored in container 1. (Measure the volume.) The probe rinse is transported to a clean room or to a site with laboratory conditions where it is split with half saved for hexavalent chromium analysis and half saved for total chromium analysis. Each sample split is ~50mL. (Measure the volumes.)

6. 2. 2 Impingers and Filter

The sampling and analytical personnel shall discuss the expected sample concentrations and the analytical limits of detection for hexavalent and total chromium. The impinger catch and filter should be handled one of two ways depending on these expectations as directed in Sections 6.2.2.1 and 6.2.2.2 below.

6. 2. 2. 1 Higher Concentrations

If it <u>is not</u> considered important to minimize the dilution of any sample component, then the contents of both impingers (~200mL total) shall be combined and stored in container 2. (Measure the volume.) As soon as possible, the filter is transported in a filter container to a site with laboratory conditions where it should be extracted in all of the impinger solution from container 2. The extraction should include shaking for a minimum of 30 minutes. The alkaline impinger medium will retard reduction of hexavalent chromium. The extract solution is split with half saved for hexavalent chromium analysis and half saved for total chromium analysis. Each sample split is ~100 mL. (Measure the volumes.)

6. 2. 2. 2 Lower Concentrations

If it <u>is</u> considered important to minimize the dilution of any sample component, then the contents of each impinger (~100mL each) may be stored in containers 2 and 3. (Measure the volumes.) The filter shall be extracted in only one of the impinger contents, whichever is suspected to have the higher concentration. The extraction shall include shaking for a minimum of 30 minutes. The contents of the first impinger are stored in container 2 and those of the second impinger in container 3. Whichever impinger contents are not used for extraction must be handled as a third sample recovery requiring separate analyses. Both sample recoveries are split as described above. Each sample split is ~50 mL. (Measure the volumes.)

6. 3 REAGENT BLANK PREPARATION

Hexavalent Chromium Reagent Blank

For each preparation, transfer 35 mL of solution to a 100mL beaker, adjust the pH to 1.0 ± 0.2 with 6N sulfuric acid, add 1.0 mL of diphenylcarbazide solution, dilute to volume with water in a 50 mL volumetric flask, and let color develop for 10 minutes.

Total Chromium Reagent Blank

For total chromium, the reagent blank is simply 1 % HNO_3.

6. 4 SAMPLE PREPARATION

6. 4. 1 Hexavalent Chromium Sample Preparation

For each preparation, transfer 35 mL of solution to a 100mL beaker, adjust the pH to 1.0 ± 0.2 with 6N sulfuric acid, add 1.0 mL of diphenylcarbazide solution, dilute to volume with water in a 50 mL volumetric flask, and let color develop for 10 minutes. (This leaves at least 15 mL of sample split for further analyses. The total volume of sample split must be known at this point.)

6. 4. 2 Total Chromium Sample Preparation

In a beaker, add 10ml of concentrated nitric acid to the sample aliquot taken for analysis. Cover the beaker with a digestion cover. Place the beaker on a hot plate and reflux the sample down to near dryness. Add another 5mL nitric acid to complete digestion. Reflux the sample volume down to near dryness.

Wash down the beaker walls and digestion cover with distilled water and filter the sample to remove silicates and other insoluble material that could clog the nebulizer. Filtration should be done only if there is concern that insoluble materials may clog the nebulizer. Adjust the volume to 50 mL or a predetermined value based on the expected metal concentrations. The final concentration of HNO_3 in the solution should be 1 % (v/v). The sample is now ready for analysis. The applicability of a sample preparation technique must be demonstrated by analyzing spiked samples and/or relevant standard reference materials.

6.5 ANALYSIS

6.5.1 Hexavalent Chromium Analysis

The analyst must filter the preparation for clarity at this point. Medium retention filter paper should be used. The filter paper shall be pre-wetted with a few mL of reagent blank and sample preparation. This will prime the filter so that it won't absorb color complex.

Transfer a portion of the filtered preparation into a 5 cm absorption cell.

Measure the absorbance at the optimum wavelength of 540 nm.

Subtract the sample blank absorbance reading to obtain a net reading.

If the absorbance reading of a sample preparation exceeds the calibration range, dilute with reagent blank or re-measure using less of the sample preparation. (There should be about 15mL remaining at this point. See Sections 6.2.1, 6.2.2.1, and 6.2.2.2.)

6.5.2 Check for Matrix Effects on the Cr(VI) Results

As the analysis for Cr(VI) by colorimetry is sensitive to the chemical composition of the sample (matrix effects), the analyst shall check at least one sample from each source using the following method: Obtain two equal volume aliquots of the same sample solution. The aliquots should each contain between 6 and 10 ug of Cr(VI) (less if not possible). Spike one of the aliquots with an aliquot of standard solution that contains between 6 and 10 ug of Cr(VI). Now treat both the spiked and unspiked sample aliquots as described in Section 6.4.1 above. Next, calculate the Cr(VI) mass Cs, in ug in the aliquot of the unspiked sample solution by using the following equation:

$$Cs = Ca \frac{As}{At-As} \qquad \text{Eq. 1}$$

where:

Ca = Cr(VI) in the standard solution, ug.

As = Absorbance of the unspiked sample solution.

At = Absorbance of the spiked sample solution.

Volume corrections will not be required since the solutions as analyzed have been made to the same final volume. If the results of this method used on the single source sample do not agree to within 10 percent of the value obtained by the routine spectrophotometric analysis, then reanalyze all samples from the source using the method of standard additions procedure.

6. 5. 3 Total Chromium Analysis

The 357.9-nm wavelength line shall be used.

Follow the manufacturer's operating instructions for all other spectrophotometer parameters.

Furnace parameters suggested by the manufacturer should be employed as guidelines. Since temperature-sensing mechanisms and temperature controllers can vary between instruments or with time, the validity of the furnace parameters must be periodically confirmed by systematically altering the furnace parameters while analyzing a standard. In this manner, losses of analyte due to higher than necessary temperature settings or losses in sensitivity due to less than optimum settings can be minimized. Similar verification of furnace parameters may be required for complex sample matrices.

Inject a measured uL aliquot of preparation into the furnace and atomize. If the concentration found exceeds the calibration range, the sample should be diluted in the same acid matrix and reanalyzed. The use of multiple injections can improve accuracy and help detect furnace pipetting errors.

Subtract a sample blank reading from a sample reading to obtain a net reading.

7 CALIBRATION, QUALITY CONTROL, AND DATA REPORTING

7. 1 GENERAL

Perform all of the calibrations described in CARB Method 5, Section 5, with any modifications appropriate for this method.

7. 2 CALIBRATION AND QUALITY CONTROL FOR HEXAVALENT CHROMIUM

7. 2. 1 Calibrate the wavelength scale of the spectrophotometer every 6 months. The calibration may be accomplished by using an energy source with an intense line emission such as a mercury lamp, or by using a series of glass filters spanning the measuring range of the spectrophotometer. Calibration materials are available commercially and from the National Institute of Standards and Technology. Specific details on the use of such materials should be supplied by the vendor; general information about calibration techniques can be obtained from general reference books on analytical chemistry. The wavelength scale of the spectrophotometer must read correctly within $\pm$5 nm at all calibration points; otherwise, the spectrophotometer shall be repaired and recalibrated. Once the wavelength scale of the spectrophotometer is in

proper calibration, use 540 nm as the optimum wavelength for the measurement of the absorbance of the standards and samples.

7.2.2 Alternatively, a scanning procedure may be employed to determine the proper measuring wavelength. If the instrument is a double-beam spectrophotometer, scan the spectrum between 530 and 550 nm using a 50 ug Cr(VI) standard solution in the sample cell and a reagent blank solution in the reference cell. If a peak does not occur, the spectrophotometer is malfunctioning and should be repaired. When a peak is obtained within the 530 to 550 nm range, the wavelength at which this peak occurs shall be the optimum wavelength for the measurement of absorbance of both the standards and the samples. For a single-beam spectrophotometer, follow the scanning procedure described above, except that the reagent blank and standard solutions shall be scanned separately. The optimum wavelength shall be the wavelength at which the maximum differences in absorbance between the standard and the reagent blank occurs.

7.2.3 Either (1) run a series of chromium standards and construct a calibration curve by plotting the concentrations of the standards against the absorbances or (2) if necessary, for the method of standard additions, plot added concentration versus absorbance.

7.2.4 Each standard for hexavalent chromium is made up fresh in a separate 50mL volumetric flask starting with 35 mL of the same batch of NaOH solution reserved for its sample set. Then an appropriate amount of hexavalent chromium is added to each calibration standard, starting with none for the zero standard. Then 6N sulfuric acid and diphenylcarbazide solution are added in the same manner as in sample preparation.

7.3 CALIBRATION AND QUALITY CONTROL FOR TOTAL CHROMIUM

7.3.1 Either (1) run a series of chromium standards and reagent blanks and construct a calibration curve by plotting the concentrations of the standards against the absorbances or (2) for the method of standard additions, plot added concentration versus absorbance. For instruments that read directly in concentration, set the curve corrector to read out the proper concentration.

Calibration standards for total chromium should start with 1% v/v HNO_3 with no chromium for the zero standard with appropriate increases in total chromium concentration in the other calibration standards. The calibration standards should be prepared following the steps outlined in sample preparation.

7. 3. 2 Run a check standard after approximately every 10 sample injections. Standards are run in part to monitor the life and performance of the graphite tube. Lack of reproducibility or a significant change in the signal for the standards indicates that the tube should be replaced.

7. 3. 3 Duplicates, spiked samples, and check standards should be routinely analyzed.

7. 3. 4 Calculate metal concentrations (1) by the method of standard additions, or (2) from a calibration curve, or (3) directly from the instrument's concentration readout. All dilution or concentration factors must be taken into account. Concentrations reported for multiphased or wet samples must be appropriately qualified (e.g., 5 ug/g dry weight).

7. 3. 5 Calibration curves must be composed of a minimum of a reagent blank and three total chromium standards. A calibration curve should be made for every batch of samples, unless check standards remain within 10% of the last calibration curve.

7. 3. 6 Dilute samples with reagent blank solution if they are more concentrated than the highest standard or if they fall on the plateau of a calibration curve.

7. 3. 7 Employ a minimum of one matrix-matched sample blank per sample batch to determine if contamination or any memory effects are occurring.

7. 3. 8 Test the system with check standards after approximately every 15 samples.

7. 3. 9 Run one duplicate sample for every 10 samples, providing there is enough sample for duplicate analysis. A duplicate sample is a sample brought through the whole sample preparation.

7. 3.10 Spiked samples or standard reference materials shall be used daily to ensure that correct procedures are being followed and that all equipment is operating properly. This will serve as a check on calibration standards, too.

7. 3.11 Whenever sample matrix problems are suspected, the method of standard additions shall be used for the analysis of all extracts, or whenever a new sample matrix is being analyzed.

7. 3.12 The concentration of all calibration standards should be verified against a quality control check sample obtained from an outside source.

7. 3.13 All quality control data should be maintained and available for easy reference or inspection.

7.4 DATA REPORTING

Carry out the calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after final calculations.

7.4.1 Total Cr(VI) in Sample

Calculate and report m_h, the total ug Cr(VI) in the sample. This can be obtained from the calibration curve or from the method of standard additions. Note that m_h is the sum of the masses of hexavalent chromium analyses performed on all sample splits. Also take in account the dilutions when calculating m_h.

Report these calculations based on net readings, but report all sample blank data, too.

7.4.2 Total Chromium in the Sample

Calculate and report m_t, the total ug of chromium in the sample. This can be obtained from the calibration curve or from the method of standard additions. Note that m_t is the sum of the masses of total chromium analyses performed on all sample splits. Also take into account the necessary dilutions when calculating out m_t.

Report these calculations based on net readings, but report all sample blank data, too.

7.4.3 Average Dry Gas Meter Temperature and Average Orifice Pressure Drop

Except where otherwise noted in this method, same as Method 5, Section 6.2.

7.4.4 Dry Gas Volume, Volume of Water Vapor, Moisture Content

Except where otherwise noted in this method, same as Method 5, Sections 6.3, 6.4, and 6.5, respectively.

7.4.5 Cr(VI) Emission Concentration

Calculate and report $[h]_s$ (g/dscm), the Cr(VI) concentration in the stack gas, dry basis, corrected to standard conditions, as follows:

$$[h]_s = (10^{-6} g/ug)(m_h/V_{m(std)})$$

7. 4. 6 Total Chromium Emission Concentration

Calculate and report $[t]_s$ (g/dscm), the total chromium concentration in the stack gas, dry basis, corrected to standard conditions as follows:

$$[t]_s = (10^{-6} g/ug)(m_t/V_{m(std)})$$

7. 4. 7 Isokinetic Variation, Acceptable Results

Except where otherwise noted in this method, same as Method 5, Sections 6.11 and 6.12, respectively.

8 REFERENCES

8. 1 US. Environmental Protection Agency/Office of Solid Waste, Washington, D.C., "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, "SW-846 (1986), Third Edition.

8. 2 Same as in Bibliography of Method 5, Citations 2 to 6 and 7.

8. 3 California Air Resources Board, Inorganic Analysis Section. (1988)

APPENDIX D

Facility Data

Amp-hrs

Run 1 Stack 2 24 July 91

TIME↓ TANKS→	183	184	185	186	187	188	190		TOTALS ↓
1030-1300 (Run 1A)	3040	2510	2810	3050	3060	3050	910	---	18,370 amp-hrs
1300-1530 (Run 1B)	3080	2560	2800	3010	3100	3100	405	---	18,055 amp-hrs

avg amp-hrs during run ---- 18,212.5 amp-hrs
rate during test

Volume meter std...
ACFM ....

Run 2 Stack 2 25 July 91

TIME↓ TANKS→	183	184	185	186	187	188	190		TOTALS ↓
0730-1000 Run 2A	3060	2340	2157	3100	3000	3000	806	---	17563 amp-hrs
1000-1230 Run 2B	3160	2120	3040	3230	3000	3220	630	---	18,700 amp-hrs

Volume meter

avg amp-hrs during run - 18,131.5 amp-hrs

Run 3 Stack 2 26 July 91

TIME	TANKS 183	184	185	186	187	188	190	TOTALS
0715-0930 Run 3B	3040	2400	3030	3060	3000	3020	60	17,610 amp hrs
0930-1200 Run 3A	3120	2440	3110	3090	3000	3160	—	17,920 amp-hrs

avg amp-hrs during run 17,765 amp-hrs

Stack 1

Run 1 29 July 91

TIME	TANK → 183	184	185	186	187	188	190	Total
Run 1A 0700-0930	3100	2270	3060	3140	3000	3080	970	18620
Run 1B 0930-1200	3200	2330	2990	3180	3000	3190	940	18830
								avg 18725

Run 2 30 July 91

Run 2A 1100-1350	3170	2800	3060	3320	2510	3340	870	19070
Run 2B 1350-1600	3160	2450	3130	3420	2590	2480 188 died at 1440	820	18050
								18560

Run 3 31 July 91

Run 3B 0700-0930	2090	1700	1700	2130	1700	dead	550	9870
Run 3A 0930-1200	3100	2310	1207	3280	2500	dead	780	13177
								11524

Total Chrome Plating Shop Hrs
documented for 91

Month	Hrs of Operations	Total Current (kamp-hrs)
Mar	825.5	587.7
Apr	663.0	388.0
May	499.0	238.7
Jun	912.0	644.6
Jul	226.0	157.9
Aug	529.0	320.1
Sep	624.0	448.7
Oct	758.0	453.0
Nov	601.0	464.8
Dec	800.0	667.1
Totals	6,537.5	4,370.5

Converting these totals for 12 months vs 10 months we have:

	7,845.0	5,244.6

APPENDIX E

Scrubber 1 Field Data

```
XROM "MASSFLO"

RUN NUMBER
ONE, STACK
             1     RUN

VOL MTR STD ?
       123.236     RUN
STACK DSCFM ?
        19,658     RUN
FRONT 1/2 MG ?
       0.00590     RUN
BACK 1/2 MG ?
             0     RUN

F  GR/DSCF = 7.3882E-7
F  MG/MMM = 1.6907E-3
F  LB/HR = 1.2449E-4
F  KG/HR = 5.6468E-5
```

```
XROM "MASSFLO"

RUN NUMBER
TWO, STACK ONE     RUN

VOL MTR STD ?
       108.215     RUN
STACK DSCFM ?
        17,255     RUN
FRONT 1/2 MG ?
        .00550     RUN
BACK 1/2 MG ?
             0     RUN

F  GR/DSCF = 7.8433E-7
F  MG/MMM = 1.7948E-3
F  LB/HR = 1.1600E-4
F  KG/HR = 5.2619E-5
```

```
XROM "MASSFLO"

RUN NUMBER
THREE, STACK ONE   RUN

VOL MTR STD ?

       118.632     RUN
STACK DSCFM ?
        19,050     RUN
FRONT 1/2 MG ?
        .00512     RUN
BACK 1/2 MG ?
             0     RUN

F  GR/DSCF = 6.6603E-7
F  MG/MMM = 1.5241E-3
F  LB/HR = 1.0875E-4
F  KG/HR = 4.9330E-5
```

```
XROM "METH 5"
RUN NUMBER
ONE, STACK 1
                    RUN
METER BOX Y?
          1.0127    RUN
DELTA H?
           .9300    RUN
BAR PRESS ?
         29.8800    RUN
METER VOL ?
        125.4900    RUN
MTR TEMP F?
         85.0000    RUN
% OTHER GAS
REMOVED BEFORE
DRY GAS METER ?
                    RUN
STATIC HOH IN ?
          -.0900    RUN
STACK TEMP.
         73.0000    RUN
ML. WATER ?
         56.0000    RUN

SAT % = 2.7

IMP. % HOH = 2.1

% HOH=2.1

% CO2?
          0.9000    RUN
% OXYGEN?
         21.0000    RUN
% CO ?
          0.0000    RUN
MOL WT OTHER?
                    RUN

MWd =28.84
MW WET=28.61
SQRT PSTS ?
          6.5791    RUN
TIME MIN ?
        240.0000    RUN
NOZZLE DIA ?
           .3100    RUN
STK DIA INCH ?
         62.0000    RUN

* VOL MTR STD = 123.276
  STK PRES ABS = 29.87
  VOL HOH GAS = 2.64
  % MOISTURE = 2.09
  MOL DRY GAS = 0.979
  % NITROGEN = 79.00
  MOL WT DRY = 28.84
  MOL WT WET = 28.61
  VELOCITY FPS = 16.14
  STACK AREA = 20.97
  STACK ACFM = 20,300.
* STACK DSCFM = 19,556.
  % ISOKINETIC =  104.54
```

```
XROM "METH 5"
RUN NUMBER
THREE, STACK 1
                    RUN
METER BOX Y?
          1.0127    RUN
DELTA H?
           .8800    RUN
BAR PRESS ?
         29.8300    RUN
METER VOL ?
        119.2420    RUN
MTR TEMP F?
         77.0000    RUN
% OTHER GAS
REMOVED BEFORE
DRY GAS METER ?
                    RUN
STATIC HOH IN ?
          -.0600    RUN
STACK TEMP.
         69.0000    RUN
ML. WATER ?
         46.5000    RUN

SAT % = 2.4

IMP. % HOH = 1.8

% HOH=1.8

% CO2?
          0.0000    RUN
% OXYGEN?
         21.0000    RUN
% CO ?
          0.0000    RUN
MOL WT OTHER?
                    RUN

MWd =28.84
MW WET=28.64
SQRT PSTS ?
          6.3093    RUN
TIME MIN ?
        240.0000    RUN
NOZZLE DIA ?
           .3110    RUN
STK DIA INCH ?
         62.0000    RUN

* VOL MTR STD = 118.632
  STK PRES ABS = 29.83
  VOL HOH GAS = 2.19
  % MOISTURE = 1.81
  MOL DRY GAS = 0.982
  % NITROGEN = 79.00
  MOL WT DRY = 28.84
  MOL WT WET = 28.64
  VELOCITY FPS = 15.50
  STACK AREA = 20.97
  STACK ACFM = 19,500.
* STACK DSCFM = 19,050.
  % ISOKINETIC =  103.16
```

```
XROM "METH 5"
RUN NUMBER
TWO, STACK 1
                    RUN
METER BOX Y?
          1.0127    RUN
DELTA H?
           .5300    RUN
BAR PRESS ?
         29.8300    RUN
METER VOL ?
        115.3390    RUN
MTR TEMP F?
        109.0000    RUN
% OTHER GAS
REMOVED BEFORE
DRY GAS METER ?
                    RUN
STATIC HOH IN ?
          -.0500    RUN
STACK TEMP.
         77.0000    RUN
ML. WATER ?
         57.6000    RUN

SAT % = 3.1

IMP. % HOH = 2.4

% HOH=2.4

% CO2?
          0.9000    RUN
% OXYGEN?
         21.0000    RUN
% CO ?
          0.0000    RUN
MOL WT OTHER?
                    RUN

MWd =28.84
MW WET=28.58
SQRT PSTS ?
          5.8319    RUN
TIME MIN ?
        240.0000    RUN
NOZZLE DIA ?
           .3110    RUN
STK DIA INCH ?
         62.0000    RUN

* VOL MTR STD = 109.215
  STK PRES ABS = 29.83
  VOL HOH GAS = 2.71
  % MOISTURE = 2.44
  MOL DRY GAS = 0.976
  % NITROGEN = 79.00
  MOL WT DRY = 28.84
  MOL WT WET = 28.58
  VELOCITY FPS = 14.35
  STACK AREA = 20.97
  STACK ACFM = 18,046.
* STACK DSCFM = 17,255.
  % ISOKINETIC =  103.9[illegible]
```

PARTICULATE SAMPLING DATA SHEET

RUN NUMBER	1 Stack #1
DATE	29 July 91
PLANT	Bldg 243 G
BASE	McClellan AFB
SAMPLE BOX NUMBER	Nutech
METER BOX NUMBER	3
Qw/Qm	
Co	

SCHEMATIC OF STACK CROSS SECTION

EQUATIONS

$°R = °F + 460$

$$H = \left[\frac{5130 \cdot Fd \cdot Cp \cdot A}{Co}\right]^2 \cdot \frac{Tm}{Ts} \cdot Vp$$

pre pitot check - good

pre train check at 16 in. Hg - Good

2% H_2O 0% other

static pressure = -0.09

$\Delta He = 2.0195$ $Y_i = 1.0127$

AMBIENT TEMP	67 (start) °F
STATION PRESS	29.880 in Hg
HEATER BOX TEMP	248 ± 25 °F
PROBE HEATER SETTING	248 ± 25
PROBE LENGTH	6 ft ~~in~~
NOZZLE AREA ~~(A)~~ d.i.	0.310 ~~0.304~~ in ~~sq ft~~
Cp	0.84
DRY GAS ~~FRACTION (Fd)~~ MW	28.84

TRAVERSE POINT NUMBER	SAMPLING TIME (min)	VAL STATIC PRESSURE (in H2O)	STACK TEMP (°F)	STACK TEMP (Ts) (°R)	VELOCITY HEAD (Vp)	ORIFICE DIFF. PRESS. (H)	GAS SAMPLE VOLUME (cu ft)	GAS METER TEMP IN (°F)	GAS METER TEMP AVG (Tm) (°R)	GAS METER TEMP OUT (°F)	SAMPLE BOX TEMP (°F)	IMPINGER OUTLET TEMP (°F)
A 1	0 start 0719	2.6	67		0.105	1.13	495.668	67		66	233	67
2	10	2.8	67		0.120	1.30	501.390	74		68	231	56
3	20	2.9	67		0.125	1.36	507.548	78		70	231	58
4	30	2.8	67		0.115	1.25	513.861	80		71	232	58
5	40	2.8	68		0.110	1.20	519.775	81		73	232	57
6	50	2.6	68		0.105	1.15	525.955	82		74	232	56
7	60	1.9	68		0.055	0.60	531.850	83		75	231	56
8	70	1.5	69		0.040	0.44	536.280	83		76	231	54
9	80	1.9	71		0.055	0.66	540.640	82		77	231	52
10	90	2.1	72		0.175	0.82	544.300	82		77	231	53
11	100	2.4	72		0.115	1.64	549.298	84		78	230	53
12	110	2.7	73		0.115	1.26	554.855	86		79	231	54
	120 0919 stop						560.975					

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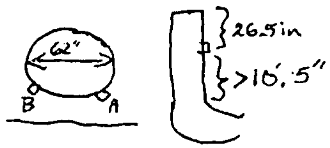
PARTICULATE SAMPLING DATA SHEET

RUN NUMBER: 1 stack #1	SCHEMATIC OF STACK CROSS SECTION	EQUATIONS	AMBIENT TEMP: °F
DATE: 29 July 91		$°R = °F + 460$	STATION PRESS: 29.880 in Hg
PLANT: Bldg 243 G		$H = \left[\frac{5130 \cdot Fd \cdot Cp \cdot A}{Co}\right]^2 \cdot \frac{Tm}{Ts} \cdot Vp$	HEATER BOX TEMP: 248±25 °F
BASE: McClellan AFB		post pitot check - good	PROBE HEATER SETTING: 248±25
SAMPLE BOX NUMBER: Nutech		post train check at 5" Hg - good	PROBE LENGTH: 6 Ft ~~in~~
METER BOX NUMBER: 3		2% H_2O	NOZZLE AREA ~~(A)~~ dia: 0.310 in ~~sq ft~~
Qw/Qm		0% other	Cp: 0.84
Co			DRY GAS ~~FRACTION (Fd)~~ MW: 28.84



duct diameter = 62"

TRAVERSE POINT NUMBER	SAMPLING TIME (min)	VAC ~~STATIC~~ PRESSURE (in Hg)	STACK TEMP (°F)	STACK TEMP (Ts) (°R)	VELOCITY HEAD (Vp)	ORIFICE DIFF. PRESS. (H)	GAS SAMPLE VOLUME (cu ft)	GAS METER TEMP IN (°F)	GAS METER TEMP AVG (Tm) (°R)	GAS METER TEMP OUT (°F)	SAMPLE BOX TEMP (°F)	IMPINGER OUTLET TEMP (°F)
B 1	0 start 0946	2.0	77		0.06	0.65	560.989	83		82	232	55
2	10	2.0	78		0.055	0.70	565.445	89		83	232	48
3	20	2.1	75		0.065	0.71	569.868	91		85	230	49
4	30	2.1	76		0.070	0.77	574.570	94		87	232	50
5	40	2.0	76		0.06	0.66	579.490	97		89	231	52
6	50	1.8	76		0.045	0.50	584.110	98		91	231	53
7	60	1.5	77		0.035	0.39	588.210	98		93	232	54
8	70	1.8	77		0.045	0.50	591.850	99		94	232	54
9	80	2.0	77		0.075	0.84	595.870	100		95	232	53
10	90	2.9	77		0.12	1.34	600.970	103		97	230	54
11	100	3.0	76		0.135	1.52	607.336	105		98	230	55
12	110	3.1	77		0.145	1.63	614.090	106		100	230	56
	(120) 1140 stop						621.172					
			$T_s = 73$		$\sqrt{\Delta P_s T_s} = 6.570$		Total $V_m = 125.49$	$T_m = 85$				
						$\overline{\Delta H} = 0.93$						

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PARTICULATE SAMPLING DATA SHEET

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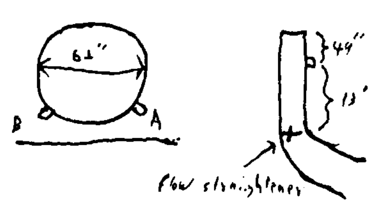
RUN NUMBER	SCHEMATIC OF STACK CROSS SECTION	EQUATIONS	AMBIENT TEMP
2 stack # 1		$^oR = ^oF + 460$	84 (start) °F
DATE: 30 July 91		$H = \left[\frac{5130 \cdot Fd \cdot Cp \cdot A}{Co}\right]^2 \cdot \frac{Tm}{Ts} \cdot Vp$	STATION PRESS: 29.830 in Hg
PLANT: Bldg 243 G		pre pitot check - good	HEATER BOX TEMP: 248 ± 25 °F
BASE: McClellan AFB		pre train check at 15" Hg - Good	PROBE HEATER SETTING: 245 ± 25
SAMPLE BOX NUMBER: Nutech			PROBE LENGTH: 6 in
METER BOX NUMBER: 3			NOZZLE AREA ~~(A)~~ dia: 0.311 inches
Qw/Qm		$P_s = -0.06$	Cp: 0.84
Co	2 % H_2O 0% other	$\Delta H@ = 2.0195$ $Y_i = 1.0127$	DRY GAS ~~FRACTION (Fd)~~ MW: 28.84

TRAVERSE POINT NUMBER	SAMPLING TIME (min)	STATIC PRESSURE (in H2O)	STACK TEMP (°F)	STACK TEMP (Ts) (°R)	VELOCITY HEAD (Vp)	ORIFICE DIFF. PRESS. (H)	GAS SAMPLE VOLUME (cu ft)	GAS METER TEMP IN (°F)	GAS METER TEMP AVG (Tm) (°R)	GAS METER TEMP OUT (°F)	SAMPLE BOX TEMP (°F)	IMPINGER OUTLET TEMP (°F)
A 1	0 start 1100	1.6	77		0.025	0.28	621.360	94		91	267	68
2	10	1.9	76		0.032	0.36	624.427	96		93	238	66
3	20	2.0	74		0.035	0.40	627.823	100		96	231	61
4	30	2.0	74		0.035	0.40	631.434	102		98	229	61
5	40	2.1	74		0.040	0.46	635.060	104		100	231	61
6	50	2.4	75		0.055	0.63	638.910	106		105	231	57
7	60	3.1	77		0.080	0.91	643.340	107		109	230	56
8	70	3.2	78		0.090	1.03	648.660	110		104	230	55
9	80	3.5	78		0.110	1.26	654.225	111		106	229	56
10	90	4.0	79		0.135	1.55	660.477	113		107	229	57
11	100	4.9	79		0.160	1.84	667.312	114		108	229	56
12	110	4.9	80		0.165	1.90	674.720	115		109	230	54
	120 1300 stop						682.300					

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PARTICULATE SAMPLING DATA SHEET

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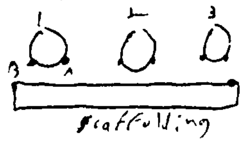
RUN NUMBER: 2 stack #1	SCHEMATIC OF STACK CROSS SECTION: scrubber stacks	EQUATIONS	AMBIENT TEMP: °F
DATE: 30 July 91		$^{\circ}R = ^{\circ}F + 460$	STATION PRESS: 29.830 in Hg
PLANT: Bldg 243 G		$H = \left[\frac{5130 \cdot Fd \cdot Cp \cdot A}{Co}\right]^2 \cdot \frac{Tm}{Ts} \cdot Vp$	HEATER BOX TEMP: 248 ± 25 °F
BASE: McClellan AFB		post pitot check –	PROBE HEATER SETTING: 248 ± 25
SAMPLE BOX NUMBER: Nutech		post train check at 8" Hg – good	PROBE LENGTH: 62 in
METER BOX NUMBER: 3			NOZZLE AREA (A) dia: 0.311 in ~~sq ft~~
Qw/Qm		Ps = -0.06	Cp: 0.84
Co	2% H_2O 0% other	ΔH@ = 2.0195 Yi = 1.0117	DRY GAS ~~FRACTION (Fd)~~ MW: 28.84



TRAVERSE POINT NUMBER	SAMPLING TIME (min)	VAC STATIC PRESSURE (in H2O)	STACK TEMP (°F)	STACK TEMP (Ts) (°R)	VELOCITY HEAD (Vp)	ORIFICE DIFF. PRESS. (H)	GAS SAMPLE VOLUME (cu ft)	GAS METER TEMP IN (°F)	GAS METER TEMP AVG (Tm) (°R)	GAS METER TEMP OUT (°F)	SAMPLE BOX TEMP (°F)	IMPINGER OUTLET TEMP (°F)
B 1	0 start 1305	2.1	86		0.045	0.57	682.302	113		111	230	62
2	10	2.6	80		0.060	0.69	686.450	114		111	232	60
3	20	2.5	78		0.055	0.69	691.115	115		112	232	62
4	30	2.5	79		0.055	0.64	695.720	115		112	232	64
5	40	2.4	79		0.052	0.60	700.320	116		113	231	64
6	50	2.5	77		0.055	0.64	704.796	117		114	231	64
7	60	2.2	80		0.045	0.52	709.365	117		114	231	64
8	70	2.3	83		0.050	0.58	713.575	117		114	230	61
9	80	2.4	83		0.055	0.63	717.955	117		115	230	56
10	90	2.5	83		0.060	0.69	722.490	117		115	230	55
11	100	2.5	83		0.060	0.69	727.210	118		115	230	56
12	110	2.5	84		0.066	0.69	731.958	119		115	225	58
	120 1505 stop						736.701					
			$\overline{T_s}$ = 77		$\sqrt{\Delta p}$'s = 5.8319							
						$\overline{\Delta H}$ = 0.58		$\overline{T_m}$ = 109				
						Total tested Vol =	115.339					

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PARTICULATE SAMPLING DATA SHEET

page 1 of 2

RUN NUMBER: 3 stack # 1

DATE: 31 July 91

PLANT: Bldg 243 G

BASE: McClellan

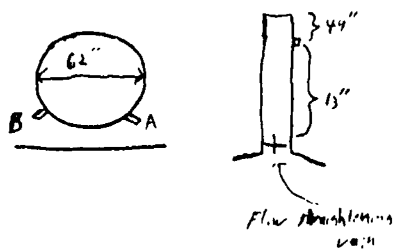
SAMPLE BOX NUMBER: Mytech

METER BOX NUMBER: 3

Qw/Qm:

Co:

SCHEMATIC OF STACK CROSS SECTION



2% H_2O 0% other

EQUATIONS

$^{\circ}R = ^{\circ}F + 460$

$$H = \left[\frac{5130 \cdot Fd \cdot Cp \cdot A}{Co}\right]^2 \cdot \frac{Tm}{Ts} \cdot Vp$$

pre pilot check – good

pre train check at 16" Hg – good

$P_r = -0.06$

$\Delta H@ = 2.0195$ $Y_i = 1.0127$

AMBIENT TEMP: 63 (start) °F

STATION PRESS: 29.830 in Hg

HEATER BOX TEMP: 248 ± 25 °F

PROBE HEATER SETTING: 248 ± 25

PROBE LENGTH: 62 in

NOZZLE AREA (A): 0.311 sq ft

Cp: 0.84

DRY GAS ~~FRACTION (Fd)~~ MW: 28.84

TRAVERSE POINT NUMBER	SAMPLING TIME (min) start	VAC ~~STATIC PRESSURE (in H2O)~~	STACK TEMP (°F)	STACK TEMP (Ts) (°R)	VELOCITY HEAD (Vp)	ORIFICE DIFF. PRESS. (H)	GAS SAMPLE VOLUME (cu ft)	GAS METER TEMP IN (°F)	GAS METER TEMP AVG (Tm) (°R)	GAS METER TEMP OUT (°F)	SAMPLE BOX TEMP (°F)	IMPINGER OUTLET TEMP (°F)
B 1	0 0711	3.1	67		0.095	~~0.95~~ 1.03	736.964	64		63	239	47
2	10	3.0	67		0.085	0.91	742.360	70		65	240	50
3	20	2.9	67		0.075	0.82	747.540	73		66	239	52
4	30	2.9	67		0.075	0.82	752.568	74		67	238	52
5	40	2.8	67		0.068	0.74	757.500	74		68	236	52
6	50	2.9	67		0.075	0.82	762.255	75		69	237	52
7	60	2.9	67		0.058	0.64	767.213	76		70	237	52
8	70	2.9	68		0.070	0.77	771.665	76		71	238	50
9	80	3.0	68		0.080	0.88	776.450	77		72	234	51
10	90	3.1	68		0.090	0.99	781.573	78		73	236	51
11	100	2.9	68		0.075	0.83	786.785	77		73	236	53
12	110	3.0	68		0.085	0.94	792.045	78		73	234	53
	120 0811 stop						797.302					

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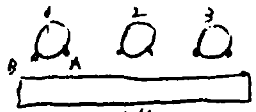
PARTICULATE SAMPLING DATA SHEET

page 2 of 2

RUN NUMBER: 3 stack #1	SCHEMATIC OF STACK CROSS SECTION	EQUATIONS	AMBIENT TEMP: °F
DATE: 31 July 91	scrubber stacks	$°R = °F + 460$	STATION PRESS: 29.830 in Hg
PLANT: Bldg 243 G		$H = \left[\frac{5130 \cdot Fd \cdot Cp \cdot A}{Co}\right]^2 \cdot \frac{Tm}{Ts} \cdot Vp$	HEATER BOX TEMP: 248 ± 25 °F
BASE: McClellan AFB	scaffolding		PROBE HEATER SETTING: 248 ± 25
SAMPLE BOX NUMBER: Nutech			PROBE LENGTH: 62 in
METER BOX NUMBER: 3			NOZZLE AREA ~~(A)~~ dia 0.311 sq ft
Qw/Qm		$P_s = -0.06$	Cp: 0.84
Co	2 % H_2O 0 % other	$\Delta H_@ = 2.0195$ $Y_i = 1.0127$	DRY GAS ~~FRACTION (Fd)~~ MW 28.84

TRAVERSE POINT NUMBER	SAMPLING TIME (min) clock	VAC ~~STATIC PRESSURE (in H2O)~~	STACK TEMP (°F)	STACK TEMP (Ts) (°R)	VELOCITY HEAD (Vp)	ORIFICE DIFF. PRESS. (H)	GAS SAMPLE VOLUME (cu ft)	GAS METER TEMP IN (°F)	GAS METER TEMP AVG (Tm) (°R)	GAS METER TEMP OUT (°F)	SAMPLE BOX TEMP (°F)	IMPINGER OUTLET TEMP (°F)
A 1	0 0916	1.5	70		0.020	0.22	797.303	76		74	237	62
2	10	1.9	69		0.032	0.35	800.020	77		74	235	55
3	20	1.9	69		0.032	0.35	803.248	78		75	236	54
4	30	2.0	69		0.035	0.39	806.578	79		76	232	55
5	40	2.0	69		0.035	0.34	810.078	81		77	238	56
6	50	2.5	69		0.058	0.64	813.590	83		79	239	55
7	60	3.0	69		0.080	0.89	817.950	85		81	235	53
8	70	3.2	70		0.100	1.12	823.080	87		82	237	53
9	80	4.0	71		0.130	1.45	828.770	89		83	238	53
10	90	4.0	73		0.132	1.47	835.202	91		84	234	54
11	100	4.9	73		0.158	1.77	841.740	92		86	236	55
12	110	5.0	74		0.170	1.90	848.853	94		87	233	55
	120 1116 stop						856.212					
		$T_s =$	69		$\overline{\sqrt{Vp}\,Ts} = 6.3093$	Total Gas	Vol = 119.242	$T_m = 77$				
						$\overline{\Delta H} = 0.88$						

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PRELIMINARY SURVEY DATA SHEET NO. 1
(Stack Geometry)

BASE: McClellan AFB	PLANT: Bldg 243 G
DATE: 29 July 91	SAMPLING TEAM: AL
SOURCE TYPE AND MAKE: Chrome Packed Bed Scrubber	
SOURCE NUMBER: stack #1 Run 1 only	INSIDE STACK DIAMETER: 62 in Inches
RELATED CAPACITY: in amp-hrs	TYPE FUEL:
DISTANCE FROM OUTSIDE OF NIPPLE TO INSIDE DIAMETER: 1.5in Inches	
NUMBER OF TRAVERSES: 2	NUMBER OF POINTS/TRAVERSE: 12

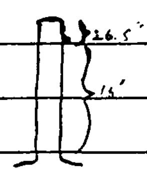
LOCATION OF SAMPLING POINTS ALONG TRAVERSE

POINT	PERCENT OF DIAMETER	DISTANCE FROM INSIDE WALL (Inches)	TOTAL DISTANCE FROM OUTSIDE OF NIPPLE TO SAMPLING POINT (Inches)
1 A, B			2.8
2 A, B			5.7
3 A, B			8.8
4 A, B			12.5
5 A, B			17.0
6 A, B			23.6
7 A, B			41.4
8 A, B			48.0
9 A, B			52.5
10 A, B			56.2
11 A, B			59.3
12 A, B			62.2

OEHL FORM APR 78 15

PRELIMINARY SURVEY DATA SHEET NO. 2
(Velocity and Temperature Traverse)

BASE: McClellan AFB	DATE: 29 July 91
BOILER NUMBER: Cr Pack Bed Scrubber - Stack one (Top port holes)	
INSIDE STACK DIAMETER: 62 in	Inches
STATION PRESSURE: 29.880	In Hg
STACK STATIC PRESSURE: -.09	In H20
SAMPLING TEAM: AL	

TRAVERSE POINT NUMBER	VELOCITY HEAD, Vp IN H20	cyclonic ~~$\sqrt{Vp}$ or~~ angle	STACK TEMPERATURE (°F)
A 1		4	62
2		6	
3		5	
4		2	
5		2	
6		0	
7		0	
8		6	
9		5	
10		8	
11		8	
12		11	
	Nozzle pre chosen from prior test data ≈ 0.310		
		avg cyclonic =	4.75°
			
	AVERAGE	4.75°	

OEHL FORM APR 78 16

PRELIMINARY SURVEY DATA SHEET NO. 1
(Stack Geometry)

BASE: McClellan AFB	PLANT: Bldg 243 G
DATE: 30 July 91	SAMPLING TEAM: AL
SOURCE TYPE AND MAKE: chrome Packed Bed Scrubber	
SOURCE NUMBER: stack #1 Runs 2&3 only	INSIDE STACK DIAMETER: 62 Inches
RELATED CAPACITY: in amp-hrs	TYPE FUEL:
DISTANCE FROM OUTSIDE OF NIPPLE TO INSIDE DIAMETER: 1.69 in Inches	
NUMBER OF TRAVERSES: 2	NUMBER OF POINTS/TRAVERSE: 12

LOCATION OF SAMPLING POINTS ALONG TRAVERSE

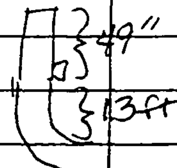
POINT	PERCENT OF DIAMETER	DISTANCE FROM INSIDE WALL (Inches)	TOTAL DISTANCE FROM OUTSIDE OF NIPPLE TO SAMPLING POINT (Inches)
1 A, B			3.0
2 A, B			5.8
3 A, B			9.0
4 A, B			12.7
5 A, B			17.2
6 A, B			23.7
7 A, B			41.6
8 A, B			48.2
9 A, B			52.7
10 A, B			56.4
11 A, B			59.5
12 A, B			62.4

OEHL FORM APR 78 15

PRELIMINARY SURVEY DATA SHEET NO. 2
(Velocity and Temperature Traverse)

BASE: McClellan AFB	DATE: 30 July 91
BOILER NUMBER: Chrome Packed Bed Scrubber 1	
INSIDE STACK DIAMETER: 62 in	Inches
STATION PRESSURE: 29.830	In Hg
STACK STATIC PRESSURE: -.06	In H20
SAMPLING TEAM: AL/OEBE	

TRAVERSE POINT NUMBER	VELOCITY HEAD, V_p IN H20	$\sqrt{V_p}$	STACK TEMPERATURE (°F)
1		24	82
2	Nozzel	18	
3	prechosen	14	
4	at	11	
5	.31"	6	
6	based on	0	
7	previous	0	
8	data	7	
9		13	
10		17	
11		19	
12		22	
		avg 12.5°	
	Port location changed for safety reasons and better		
	comply with Method 1 (EPA and ARB)		
Straightening Vain installed because	cyclonicity > 20° on	first attempt	
	AVERAGE		



OEHL FORM APR 78 16

AIR POLLUTION PARTICULATE A[illegible] .YTICAL DATA

BASE	DATE	RUN NUMBER
McClellan AFB	29 Jul 91	1 Stack 1

BUILDING NUMBER	SOURCE NUMBER
Bldg 243 G	

I. PARTICULATES

ITEM	FINAL WEIGHT (gm)	INITIAL WEIGHT (gm)	WEIGHT PARTICLES (gm)
FILTER NUMBER			
ACETONE WASHINGS *(Probe, Front Half Filter)*			
BACK HALF *(If needed)*			
	Total Weight of Particulates Collected		gm

II. WATER

ITEM	FINAL WEIGHT (gm)	INITIAL WEIGHT (gm)	WEIGHT WATER (gm)
IMPINGER 1 *(H20)* 0.1 N NaOH	123	100	23.0
IMPINGER 2 *(H20)* 0.1 N NaOH	106	100	6.0
IMPINGER 3 *(Dry)*			
IMPINGER 4 *(Silica Gel)*	227	200	27.0
	Total Weight of Water Collected		56.0 gm

III. GASES *(Dry)*

ITEM	ANALYSIS 1	ANALYSIS 2	ANALYSIS 3	ANALYSIS 4	AVERAGE
VOL % CO_2	probe pre-wash = 100 ml				
VOL % O_2	probe post wash = 140 ml				
VOL % CO					
VOL % N_2					

Vol % N_2 = (100% - % CO_2 - % O_2 - % CO)

OEHL FORM MAY 78 20

AIR POLLUTION PARTICULATE ANALYTICAL DATA

BASE	DATE	RUN NUMBER
McClellan AFB	31 Jul 91	3 stack 1

BUILDING NUMBER	SOURCE NUMBER
Bldg 243 E	

I. PARTICULATES

ITEM	FINAL WEIGHT (gm)	INITIAL WEIGHT (gm)	WEIGHT PARTICLES (gm)
FILTER NUMBER			
ACETONE WASHINGS *(Probe, Front Half Filter)*			
BACK HALF *(If needed)*			
	Total Weight of Particulates Collected		gm

II. WATER

ITEM	FINAL WEIGHT (gm)	INITIAL WEIGHT (gm)	WEIGHT WATER (gm)
IMPINGER 1 ~~(H2O)~~ 0.1 N NaOH	122 ml	100 ml	22 ml
IMPINGER 2 ~~(H2O)~~ 0.1 N NaOH	104 ml	100 ml	4 ml
IMPINGER 3 *(Dry)*			
IMPINGER 4 *(Silica Gel)*	220.5	200	20.5
	Total Weight of Water Collected		46.5 gm

III. GASES *(Dry)*

ITEM	ANALYSIS 1	ANALYSIS 2	ANALYSIS 3	ANALYSIS 4	AVERAGE
VOL % CO_2	probe pre-	wash =	100 ml		
VOL % O_2	probe post-	wash =	12 ml		
VOL % CO					
VOL % N_2					

Vol % N_2 = (100% - % CO_2 - % O_2 - % CO)

OEHL FORM MAY 78 20

AIR POLLUTION PARTICULATE ANALYTICAL DATA

BASE	DATE	RUN NUMBER
McClellan AFB	30 Jul 91	2 Stack 1

BUILDING NUMBER	SOURCE NUMBER
Bldg 243 G	

I. PARTICULATES

ITEM	FINAL WEIGHT (gm)	INITIAL WEIGHT (gm)	WEIGHT PARTICLES (gm)
FILTER NUMBER			
ACETONE WASHINGS *(Probe, Front Half Filter)*			
BACK HALF *(If needed)*			
	Total Weight of Particulates Collected		gm

II. WATER

ITEM	FINAL WEIGHT (gm)	INITIAL WEIGHT (gm)	WEIGHT WATER (gm)
IMPINGER 1 *(H20)* 0.1 N NaOH	133	100	33 ml
IMPINGER 2 *(H20)* 0.1 N NaOH	103	100	03 ml
IMPINGER 3 *(Dry)*			
IMPINGER 4 *(Silica Gel)*	221.6	200	21.6
	Total Weight of Water Collected		57.6 gm

III. GASES *(Dry)*

ITEM	ANALYSIS 1	ANALYSIS 2	ANALYSIS 3	ANALYSIS 4	AVERAGE
VOL % CO_2	Probe	pre-wash =	100ml		
VOL % O_2	probe	post-wash =	130ml		
VOL % CO					
VOL % N_2					

Vol % N_2 = (100% - % CO_2 - % O_2 - % CO)

OEHL FORM MAY 78 20

APPENDIX F

Scrubber 2 Field Data

```
              XROM "METH 5"
RUN NUMBER
ONE, STACK 2
                          RUN
METER BOX Y?
               1.0127     RUN
DELTA H?
                .8300     RUN
BAR PRESS ?
              29.8700     RUN
METER VOL ?
             118.2020     RUN
MTR TEMP F?
              88.0000     RUN
% OTHER GAS
REMOVED BEFORE
DRY GAS METER ?
                          RUN
STATIC HOH IN ?
               -.1600     RUN
STACK TEMP.
             101.0000     RUN
ML. WATER ?
              51.3000     RUN
SAT % = 6.7

IMP. % HOH = 2.0

% HOH=2.0

% CO2?
               0.0000     RUN
% OXYGEN?
              21.0000     RUN
% CO ?
               0.9000     RUN
MOL WT OTHER?
                          RUN

MWd =28.84
MW WET=28.62
SQRT PSTS ?
               6.4195     RUN
TIME MIN ?
             240.0000     RUN
NOZZLE DIA ?
                .3100     RUN
STK DIA INCH ?
              62.0000     RUN

* VOL MTR STD = 115.377
  STK PRES ABS = 29.86
  VOL HOH GAS = 2.41
  % MOISTURE = 2.05
  MOL DRY GAS = 0.980
  % NITROGEN = 79.00
  MOL WT DRY = 28.84
  MOL WT WET = 28.62
  VELOCITY FPS = 15.77
  STACK AREA = 20.97
  STACK ACFM = 19.839.
* STACK DSCFM = 18.251.
  % ISOKINETIC = 105.42
```

```
              XROM "METH 5"
RUN NUMBER
TWO, STACK 2
                          RUN
METER BOX Y?
               1.0127     RUN
DELTA H?
                .9000     RUN
BAR PRESS ?
              29.8000     RUN
METER VOL ?
             122.9230     RUN
MTR TEMP F?
              80.0000     RUN
% OTHER GAS
REMOVED BEFORE
DRY GAS METER ?
                          RUN
STATIC HOH IN ?
               -.1600     RUN
STACK TEMP.
              70.0000     RUN
ML. WATER ?
              46.3000     RUN
SAT % = 2.5

IMP. % HOH = 1.8

% HOH=1.8

% CO2?
               0.0000     RUN
% OXYGEN?
              21.0000     RUN
% CO ?
               0.9000     RUN
MOL WT OTHER?
                          RUN

MWd =28.84
MW WET=28.65

SQRT PSTS ?
               6.4649     RUN
TIME MIN ?
             240.0000     RUN
NOZZLE DIA ?
                .3000     RUN
STK DIA INCH ?
              62.0000     RUN

* VOL MTR STD = 121.495
  STK PRES ABS = 29.79
  VOL HOH GAS = 2.18
  % MOISTURE = 1.76
  MOL DRY GAS = 0.982
  % NITROGEN = 79.00
  MOL WT DRY = 28.84
  MOL WT WET = 28.65
  VELOCITY FPS = 15.89
  STACK AREA = 20.97
  STACK ACFM = 19.991.
* STACK DSCFM = 19.479.
  % [illegible] = [illegible]
```

```
              XROM "METH 5"
RUN NUMBER
THREE, STACK 2
                          RUN
METER BOX Y?
               1.0127     RUN
DELTA H?
                .9900     RUN
BAR PRESS ?
              29.9050     RUN
METER VOL ?
             129.0620     RUN
MTR TEMP F?
              81.0000     RUN
% OTHER GAS
REMOVED BEFORE
DRY GAS METER ?
                          RUN
STATIC HOH IN ?
               -.1600     RUN
STACK TEMP.
              70.0000     RUN
ML. WATER ?
              46.2000     RUN
SAT % = 2.5

IMP. % HOH = 1.7

% HOH=1.7

% CO2?
               0.0000     RUN
% OXYGEN?
              21.0000     RUN
% CO ?
               0.0000     RUN
MOL WT OTHER?
                          RUN

MWd =28.84
MW WET=28.66

SQRT PSTS ?
               6.6517     RUN
TIME MIN ?
             240.0000     RUN
NOZZLE DIA ?
                .3130     RUN
STK DIA INCH ?
              62.0000     RUN

* VOL MTR STD = [illegible]
  STK PRES ABS = [illegible]
  VOL HOH GAS = [illegible]
  % MOISTURE = [illegible]
  MOL DRY GAS = [illegible]
  % NITROGEN = [illegible]
  MOL WT DRY = [illegible]
  MOL WT WET = [illegible]
  VELOCITY FPS = [illegible]
  STACK AREA = 20.97
  STACK ACFM = [illegible]
* STACK DSCFM = [illegible]
  % ISOKINETIC = [illegible]
```

```
XROM "MASSFLO"

RUN NUMBER
ONE, STACK TWO        RUN

VOL MTR STD ?

         115.377      RUN
STACK DSCFM ?
          18,251      RUN
FRONT 1/2 MG ?
          .00552      RUN
BACK 1/2 MG ?
               0      RUN


F  GR/DSCF = 7.3832E-7
F  MG/MMM = 1.6895E-3
F  LB/HR = 1.1550E-4
F  KG/HR = 5.2391E-5
```

```
XROM "MASSFLO"

RUN NUMBER
TWO, STACK TWO        RUN

VOL MTR STD ?
         121.498      RUN
STACK DSCFM ?
          19,479      RUN
FRONT 1/2 MG ?
          .00516      RUN
                      RUN

BACK 1/2 MG ?
               0      RUN


F  GR/DSCF = 6.5540E-7
F  MG/MMM = 1.4998E-3
F  LB/HR = 1.0943E-4
F  KG/HR = 4.9636E-5
```

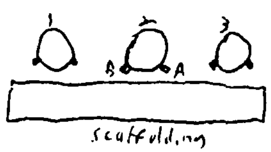
```
XROM "MASSFLO"

RUN NUMBER
THREE, STACK TWO      RUN

VOL MTR STD ?
          127.38      RUN
STACK DSCFM ?
          20,057      RUN
FRONT 1/2 MG ?
          .00554      RUN
BACK 1/2 MG ?
               0      RUN


F  GR/DSCF = 6.7117E-7
F  MG/MMM = 1.5359E-3
F  LB/HR = 1.1539E-4
F  KG/HR = 5.2339E-5
```

PARTICULATE SAMPLING DATA SHEET

Page 1 of 2

RUN NUMBER	1 stack # 2
DATE	24 July 91
PLANT	Bldg 243G
BASE	McClellan AFB
SAMPLE BOX NUMBER	Nutech
METER BOX NUMBER	3
Qw/Qm	
Co	

SCHEMATIC OF STACK CROSS SECTION



EQUATIONS

$^{o}R = {}^{o}F + 460$

$$H = \left[\frac{5130 \cdot Fd \cdot Cp \cdot A}{Co}\right]^2 \cdot \frac{Tm}{Ts} \cdot Vp$$

pre pitot check - Good

pre train check at 15 in Hg - Good

2% H_2O 0% other

static pressure = $^{-}0.16$

$\Delta H@ = 2.0195$ $Y_i = 1.0129$

AMBIENT TEMP	82 (start) °F
STATION PRESS	29.870 in Hg
HEATER BOX TEMP	248 ± 25 °F
PROBE HEATER SETTING	248 ± 25
PROBE LENGTH	6 ft
NOZZLE ~~AREA (A)~~ dia	0.310 in
Cp	0.84
DRY GAS ~~FRACTION (Fd)~~ MW	28.84

TRAVERSE POINT NUMBER	SAMPLING TIME (min)	VAC ~~STATIC PRESSURE~~ (in Hg)	STACK TEMP (°F)	STACK TEMP (Ts) (°R)	VELOCITY HEAD (Vp)	ORIFICE DIFF. PRESS. (H)	GAS SAMPLE VOLUME (cu ft)	GAS METER TEMP IN (°F)	GAS METER TEMP AVG (Tm) (°R)	GAS METER TEMP OUT (°F)	SAMPLE BOX TEMP (°F)	IMPINGER OUTLET TEMP (°F)
A 1	0 start 1055	3.0	85		0.140	1.47	123.718	74		73	253	67
2	10	3.1	88		0.155	1.63	130.300	77		75	252	66
3	20	3.1	90		0.150	1.58	137.340	83		80	248	63
4	30	3.0	93		0.140	1.48	144.160	86		81	246	61
5	40	2.7	93		0.115	1.22	150.388	88		84	241	62
6	50	2.4	93		0.095	1.00	157.082	85		82	245	60
7	60	1.7	95		0.045	0.47	162.775	85		83	247	59
8	70	1.3	96		0.030	0.32	166.850	85		84	251	63
9	80	1.5	97		0.040	0.42	170.181	85		84	253	63
10	90	2.1	98		0.060	0.63	173.831	85		85	251	59
11	100	2.2	97		0.070	0.73	178.227	84		83	252	54
12	110	2.3	98		0.080	0.84	183.008	85		85	248	53
	120 1255 stop						188.125					

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PARTICULATE SAMPLING DATA SHEET

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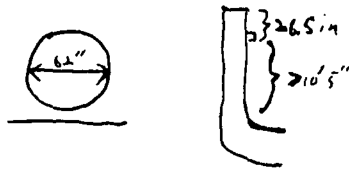
RUN NUMBER	1 stack #2
DATE	24 July 91
PLANT	Bldg 243 B
BASE	McClellan
SAMPLE BOX NUMBER	Nutech
METER BOX NUMBER	3
Qw/Qm	
Co	

SCHEMATIC OF STACK CROSS SECTION



EQUATIONS

$^{o}R = {^{o}F} + 460$

$$H = \left[\frac{5130 \cdot Fd \cdot Cp \cdot A}{Co}\right]^2 \cdot \frac{Tm}{Ts} \cdot Vp$$

post pitot check - good

post train check at 14 in Hg - good

AMBIENT TEMP	°F
STATION PRESS	29.870 in Hg
HEATER BOX TEMP	248 ± 25 °F
PROBE HEATER SETTING	248 ± 25
PROBE LENGTH	6 ft
NOZZLE AREA ~~(A)~~ dia	0.310 in ~~sq ft~~
Cp	0.84
DRY GAS ~~FRACTION (Fd)~~ Mw	28.84

TRAVERSE POINT NUMBER	SAMPLING TIME (min)	VAC STATIC PRESSURE (in ~~H2O~~)	STACK TEMP (°F)	STACK TEMP (Ts) (°R)	VELOCITY HEAD (Vp)	ORIFICE DIFF. PRESS. (H)	GAS SAMPLE VOLUME (cu ft)	GAS METER TEMP IN (°F)	GAS METER TEMP AVG (Tm) (°R)	GAS METER TEMP OUT (°F)	SAMPLE BOX TEMP (°F)	IMPINGER OUTLET TEMP (°F)
B 1	0 1327 start	1.7	104		0.04	0.42	188.250	93		91	243	65
2	10	1.6	106		0.045	0.47	192.058	88		89	243	58
3	20	1.8	106		0.05	0.52	195.650	90		90	243	57
4	30	1.8	107		0.045	0.47	199.825	93		92	244	55
5	40	1.6	106		0.045	0.47	203.745	93		92	250	57
6	50	1.5	107		0.035	0.37	207.778	94		94	255	57
7	60	1.5	107		0.035	0.37	211.250	95		95	253	58
8	70	1.6	108		0.040	0.42	214.782	96		97	257	59
9	80	2.1	109		0.075	0.79	218.510	96		97	265	54
10	90	2.5	109		0.10	1.05	223.445	95		94	218	54
11	100	2.7	110		0.125	1.31	229.075	97		95	259	56
12	110	3.0	110		0.145	1.52	235.341	97		96	264	57
	120						242.045					
								$\bar{T}_m = 88$				
			$\bar{T}_s = 101$		$\sqrt{\Delta P_s} = 0.4195$		Total Gas Vol =	114.202				
						$\overline{\Delta H} = 0.83$						

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PARTICULATE SAMPLING DATA SHEET

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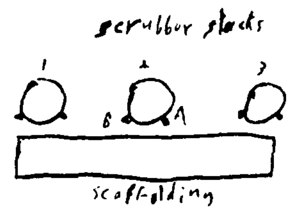
RUN NUMBER	2 Stack 2
DATE	25 July 91
PLANT	Bldg 243 C
BASE	McClellan AFB
SAMPLE BOX NUMBER	Nutech
METER BOX NUMBER	3
Qw/Qm	
Co	

SCHEMATIC OF STACK CROSS SECTION



2% H_2O 0% other

EQUATIONS

$^{\circ}R = ^{\circ}F + 460$

$$H = \left[\frac{5130 \cdot Fd \cdot Cp \cdot A}{Co}\right]^2 \cdot \frac{Tm}{Ts} \cdot Vp$$

pre pitot check - good

pre train check at 15 in Hg - good

post pitot check - good

post train check at 5 in Hg - good

static pressure = -0.16

$\Delta H@ = 2.0195$

$Y_i = 1.0127$

AMBIENT TEMP	64 (at start) °F
STATION PRESS	29.800 in Hg
HEATER BOX TEMP	248 ± 25 °F
PROBE HEATER SETTING	248 ± 25
PROBE LENGTH	6 ft ~~in~~
NOZZLE AREA (A)	0.309 sq ft
Cp	0.84
DRY GAS ~~FRACTION (Fd)~~ MW	28.84

TRAVERSE POINT NUMBER	SAMPLING TIME (min)	VAC ~~STATIC PRESSURE~~ (in Hg)	STACK TEMP (°F)	STACK TEMP (Ts) (°R)	VELOCITY HEAD (Vp)	ORIFICE DIFF. PRESS. (H)	GAS SAMPLE VOLUME (cu ft)	GAS METER TEMP IN (°F)	GAS METER TEMP AVG (Tm) (°R)	GAS METER TEMP OUT (°F)	SAMPLE BOX TEMP (°F)	IMPINGER OUTLET TEMP (°F)
A 1	0 start 0752	4.0	63		0.125	1.32	242.316	63	0	62	265	52
2	10	4.8	64		0.150	1.60	248.570	70		64	258	48
3	20	5.0	65		0.165	1.76	255.326	74		65	255	50
4	30	4.5	65		0.140	1.50	262.455	76		67	255	54
5	40	4.0	65		0.120	1.29	269.160	77		68	255	53
6	50	3.4	65		0.110	1.08	275.365	78		70	254	51
7	60	2.5	65		0.055	0.57	281.090	78		71	253	51
8	70	2.0	67		0.040	0.43	285.450	77		71	254	49
9	80	1.9	69		0.035	0.37	289.185	77		72	254	48
10	90	2.1	69		0.045	0.48	292.625	77		73	254	50
11	100	2.9	74		0.075	0.80	296.412	80		75	251	47
12	110	3.0	71		0.080	0.86	301.360	82		75	253	50
	120 0952 stop						306.516					

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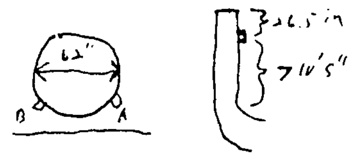
PARTICULATE SAMPLING DATA SHEET

RUN NUMBER	2 Stack 2
DATE	25 Jul 91
PLANT	Bldg 243 G
BASE	McClellan AFB
SAMPLE BOX NUMBER	Nutech
METER BOX NUMBER	3
Qw/Qm	
Co	

SCHEMATIC OF STACK CROSS SECTION



EQUATIONS

$$^{\circ}R = {}^{\circ}F + 460$$

$$H = \left[\frac{5130 \cdot Fd \cdot Cp \cdot A}{Co}\right]^2 \cdot \frac{Tm}{Ts} \cdot Vp$$

AMBIENT TEMP	°F
STATION PRESS	29.800 in Hg
HEATER BOX TEMP	248 ± 25 °F
PROBE HEATER SETTING	248 ± 25
PROBE LENGTH	6 FT in
NOZZLE AREA (A)	0.309 sq ft
Cp	0.84
DRY GAS ~~FRACTION (Fd)~~ MW	28.84

TRAVERSE POINT NUMBER	SAMPLING TIME (min)	STATIC PRESSURE (in H20)	STACK TEMP (°F)	STACK TEMP (Ts) (°R)	VELOCITY HEAD (Vp)	ORIFICE DIFF. PRESS. (H)	GAS SAMPLE VOLUME (cu ft)	GAS METER TEMP IN (°F)	GAS METER TEMP AVG (Tm) (°R)	GAS METER TEMP OUT (°F)	SAMPLE BOX TEMP (°F)	IMPINGER OUTLET TEMP (°F)
B 1	0 start 1034	2.5	74		0.06	0.64	306.524	79		78	256	48
2	10	2.3	74		0.055	0.59	310.960	83		79	256	48
3	20	2.3	73		0.055	0.59	315.305	85		80	254	50
4	30	2.3	72		0.055	0.60	319.615	87		82	256	50
5	40	2.2	73		0.052	0.56	323.990	89		83	258	50
6	50	2.8	73		0.06	0.65	328.235	90		85	257	50
7	60	2.2	73		0.052	0.57	332.790	92		86	257	50
8	70	2.2	73		0.052	0.57	337.083	92		87	255	50
9	80	2.8	73		0.065	0.71	341.367	93		88	255	50
10	90	3.1	73		0.083	0.91	346.080	94		89	255	52
☆ 11	100	3.8	73		0.125	1.37	351.375	95		91	258	54
12	110	4.8	74		0.155	1.70	358.08	93		92	242	57
	120 1232 stop						365.247					
			$\overline{T_s}$ = 70		$\overline{\sqrt{P_s T_s}}$ = 6.4649		Total Gas Vol = 122.423	$\overline{T_m}$ = 80				
						$\overline{\Delta H}$ = 0.90						

☆ Vacuum pump stopped working at 100.4 min (1144 hrs). Pump replaced and sampling restarted at 1202 hrs

OEHL FORM MAY 78 18

PARTICULATE SAMPLING DATA SHEET

page 1 of 2

RUN NUMBER: Three   Stack 2

DATE: 26 July 91

PLANT: Bldg 243 B

BASE: McClellan AFB

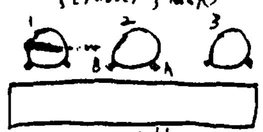
SAMPLE BOX NUMBER: Nutech

METER BOX NUMBER: 3

Qw/Qm:

Co:

SCHEMATIC OF STACK CROSS SECTION



2% H_2O 0% other

EQUATIONS

$^{o}R = {}^{o}F + 460$

$$H = \left[\frac{5130 \cdot Fd \cdot Cp \cdot A}{Co}\right]^2 \cdot \frac{Tm}{Ts} \cdot Vp$$

pre pitot check - good

pre train check at 15 in Hg - good

static pressure = -0.16

$\Delta H@ = 2.0195$ $Y_i = 1.0127$

AMBIENT TEMP: 65 (start) °F

STATION PRESS: 29.805 in Hg

HEATER BOX TEMP: 248 ± 25 °F

PROBE HEATER SETTING: 248 ± 25

PROBE LENGTH: 6 ft ~~in~~

NOZZLE ~~AREA (A)~~ dia: 0.313 in ~~sq ft~~

Cp: 0.84

DRY GAS ~~FRACTION (Fd)~~ MW: 28.84

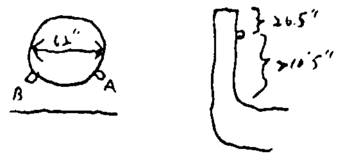
TRAVERSE POINT NUMBER	SAMPLING TIME (min)	VAC ~~STATIC PRESSURE (in H2O)~~	STACK TEMP (°F)	STACK TEMP (Ts) (°R)	VELOCITY HEAD (Vp)	ORIFICE DIFF. PRESS. (H)	GAS SAMPLE VOLUME (cu ft)	GAS METER TEMP IN (°F)	GAS METER TEMP AVG (Tm) (°R)	GAS METER TEMP OUT (°F)	SAMPLE BOX TEMP (°F)	IMPINGER OUTLET TEMP (°F)
B 1	0 start 0704	1.8	66		0.045	0.50	365.440	65		66	241	56
2	10	2.1	66		0.06	0.67	369.327	69		66	246	52
3	20	2.1	67		0.065	0.73	373.772	73		67	244	53
4	30	2.1	67		0.065	0.73	378.470	75		69	245	54
5	40	2.1	67		0.065	0.73	383.187	76		69	245	55
6	50	1.0	67		0.06	0.68	387.900	77		71	243	65
7	60	0.9	67		0.05	0.57	392.470	79		72	241	66
8	70	1.0	67		0.06	0.68	396.706	79		73	228	64
9	80	1.0	67		0.085	0.97	401.260	80		74	238	64
10	90	1.0	67		0.105	1.19	406.652	81		75	232	66
11	100	1.1	68		0.14	1.59	412.585	83		76	232	67
12	110	1.1	68		0.165	1.88	419.370	84		77	232	63
	120 0904 stop						426.777					

OEHL FORM MAY 78 18

PARTICULATE SAMPLING DATA SHEET

RUN NUMBER	Three stack 2
DATE	26 July 91
PLANT	Bldg 243 G
BASE	McClellan AFB
SAMPLE BOX NUMBER	Nutech
METER BOX NUMBER	3
Qw/Qm	
Co	

SCHEMATIC OF STACK CROSS SECTION



EQUATIONS

$^{o}R = {^{o}F} + 460$

$$H = \left[\frac{5130 \cdot Fd \cdot Cp \cdot A}{Co}\right]^2 \cdot \frac{Tm}{Ts} \cdot Vp$$

post pitot check - Good

post train check at 13 in Hg - Good

AMBIENT TEMP	°F
STATION PRESS	29.845 in Hg
HEATER BOX TEMP	248 ± 25 °F
PROBE HEATER SETTING	248 ± 25
PROBE LENGTH	6 ft
NOZZLE ~~AREA (A)~~ dia	0.313 in ~~sq ft~~
Cp	0.84
DRY GAS ~~FRACTION (Fd)~~ MW	28.84

TRAVERSE POINT NUMBER	SAMPLING TIME (min)	VAC ~~STATIC~~ PRESSURE (in Hg)	STACK TEMP (°F)	STACK TEMP (Ts) (°R)	VELOCITY HEAD (Vp)	ORIFICE DIFF. PRESS. (H)	GAS SAMPLE VOLUME (cu ft)	GAS METER TEMP IN (°F)	GAS METER TEMP AVG (Tm) (°R)	GAS METER TEMP OUT (°F)	SAMPLE BOX TEMP (°F)	IMPINGER OUTLET TEMP (°F)
A 1	0 start 0907	1.0	70		0.135	1.53	426.780	80		78	233	64
2	10	1.6	70		0.150	1.71	433.500	85		79	230	65
3	20	1.0	69		0.135	1.55	440.545	87		80	236	63
4	30	1.0	70		0.115	1.32	447.450	89		81	231	63
5	40	1.0	70		0.10	1.15	453.815	90		82	231	68
6	50	1.0	72		0.10	1.15	459.745	91		84	231	64
7	60	1.0	73		0.05	0.57	465.310	91		85	229	67
8	70	1.0	74		0.045	0.52	469.950	93		87	229	67
9	80	1.0	75		0.042	0.48	474.195	93		89	232	68
10	90	1.0	75		0.065	0.75	478.170	94		90	231	66
11	100	1.0	75		0.085	0.98	482.989	96		91	231	68
12	110	1.0	76		0.105	1.21	488.520	98		92	227	68
	120 stop 1109						494.505					

$\bar{T}_m = 81$

$\bar{T}_s = 70$ $\overline{\sqrt{\Delta P_s T_s}} = 6.1577$ Total Gas Vol = 129.062

$\overline{\Delta H} = 0.99$

OEHL FORM 18 MAY 78

PRELIMINARY SURVEY DATA SHEET NO. 2
(Velocity and Temperature Traverse)

BASE: McClellan AFB	DATE: 24 July 91
BOILER NUMBER: Chrome Packed Bed Scrubber stack 2	
INSIDE STACK DIAMETER: 62 Inches	
STATION PRESSURE: 29.870 In Hg	
STACK STATIC PRESSURE: -0.16 In H20	
SAMPLING TEAM: AL	

TRAVERSE POINT NUMBER	VELOCITY HEAD, Vp IN H20	cyclonicity	STACK TEMPERATURE (°F)
A 1	nozzle	2	63
2	prechosen	12	
3	from	10	
4	pilot	8	
5	test	7	
6	data	7	
7	~0.310	4	
8		5	
9		5	
10		9	
11		11	
12		15	
		avg cycl 7.92(degrees)	
AVERAGE			

OEHL FORM APR 78 16

PRELIMINARY SURVEY DATA SHEET NO. 1
(Stack Geometry)

BASE: McClellan	PLANT: Bldg 243 G
DATE: 24 July 91	SAMPLING TEAM: AL
SOURCE TYPE AND MAKE: chrome packed bed scrubber	
SOURCE NUMBER: scrubber stack #2	INSIDE STACK DIAMETER: 62 Inches
RELATED CAPACITY: in amp-hrs	TYPE FUEL
DISTANCE FROM OUTSIDE OF NIPPLE TO INSIDE DIAMETER: 1.5 in Inches	
NUMBER OF TRAVERSES: 2	NUMBER OF POINTS/TRAVERSE: 12

LOCATION OF SAMPLING POINTS ALONG TRAVERSE

POINT	PERCENT OF DIAMETER	DISTANCE FROM INSIDE WALL *(Inches)*	TOTAL DISTANCE FROM OUTSIDE OF NIPPLE TO SAMPLING POINT *(Inches)*
1 A/B			2.8
2 A/B			5.7
3 A/B			8.8
4 A/B			12.5
5 A/B			17.0
6 A/B			23.6
7 A/B			41.4
8 A/B			48.0
9 A/B			52.5
10 A/B			56.2
11 A/B			59.3
12 A/B			62.2

OEHL FORM APR 78 15

AIR POLLUTION PARTICULATE ANALYTICAL DATA

BASE	DATE	RUN NUMBER
McClellan AFB	26 July 91	3

BUILDING NUMBER	SOURCE NUMBER
Bldg 243 b	stack # 2

I. PARTICULATES

ITEM	FINAL WEIGHT (gm)	INITIAL WEIGHT (gm)	WEIGHT PARTICLES (gm)
FILTER NUMBER			
ACETONE WASHINGS *(Probe, Front Half Filter)*			
BACK HALF *(If needed)*			
	Total Weight of Particulates Collected		gm

II. WATER

ITEM	FINAL WEIGHT (gm)	INITIAL WEIGHT (gm)	WEIGHT WATER (gm)
IMPINGER 1 *(H20)* 0.1 N NaOH	120 ml	100 ml	20 ml
IMPINGER 2 *(H20)* 0.1 N NaOH	108 ml	100 ml	8 ml
IMPINGER 3 *(Dry)*			
IMPINGER 4 *(Silica Gel)*	218.2	200	18.2
	Total Weight of Water Collected		46.2 gm

III. GASES *(Dry)*

ITEM	ANALYSIS 1	ANALYSIS 2	ANALYSIS 3	ANALYSIS 4	AVERAGE
VOL % CO_2	probe pre-wash = 110 ml				
VOL % O_2	probe post-wash = 109 ml				
VOL % CO					
VOL % N_2					

Vol % N_2 = (100% - % CO_2 - % O_2 - % CO)

OEHL FORM MAY 78 20

AIR POLLUTION PARTICULATE ANALYTICAL DATA

BASE	DATE	RUN NUMBER
McClellan AFB	24 July 91	stack 2 # 1

BUILDING NUMBER	SOURCE NUMBER
	stack 2

I. PARTICULATES

ITEM	FINAL WEIGHT (gm)	INITIAL WEIGHT (gm)	WEIGHT PARTICLES (gm)
FILTER NUMBER			
ACETONE WASHINGS *(Probe, Front Half Filter)*			
BACK HALF *(If needed)*			
	Total Weight of Particulates Collected		gm

II. WATER

ITEM	FINAL WEIGHT (gm)	INITIAL WEIGHT (gm)	WEIGHT WATER (gm)
IMPINGER 1 *(H20)* 0.1 N NaOH	120.0	100	20.0
IMPINGER 2 *(H20)* 0.1 N NaOH	108.0	100	8.0
IMPINGER 3 *(Dry)*			
IMPINGER 4 *(Silica Gel)*	223.3	200	23.3
	Total Weight of Water Collected		51.3 gm

III. GASES *(Dry)*

ITEM	ANALYSIS 1	ANALYSIS 2	ANALYSIS 3	ANALYSIS 4	AVERAGE
VOL % CO_2	probe prewash = 170 ml		0.1 NaOH		
VOL % O_2	probe wash = 108 ml		0.1 NaOH		
VOL % CO					
VOL % N_2					

Vol % N_2 = (100% - % CO_2 - % O_2 - % CO)

OEHL FORM MAY 78 20

AIR POLLUTION PARTICULATE ANALYTICAL DATA

BASE	DATE	RUN NUMBER
McClellan AFB	25 July 79	2 Stack 2

BUILDING NUMBER	SOURCE NUMBER

I. PARTICULATES

ITEM	FINAL WEIGHT (gm)	INITIAL WEIGHT (gm)	WEIGHT PARTICLES (gm)
FILTER NUMBER			
ACETONE WASHINGS *(Probe, Front Half Filter)*			
BACK HALF *(If needed)*			
	Total Weight of Particulates Collected		gm

II. WATER

ITEM	FINAL WEIGHT (gm)	INITIAL WEIGHT (gm)	WEIGHT WATER (gm)
IMPINGER 1 *(H20)* 0.1 N NaOH	117.5	100.0	17.5
IMPINGER 2 *(H20)* 0.1 N NaOH	106.0	100.0	6.0
IMPINGER 3 *(Dry)*			
IMPINGER 4 *(Silica Gel)*	222.8	200.0	22.8
	Total Weight of Water Collected		46.3 gm

III. GASES *(Dry)*

ITEM	ANALYSIS 1	ANALYSIS 2	ANALYSIS 3	ANALYSIS 4	AVERAGE
VOL % CO_2	Prewash Vol (Probe) = 116 ml				
VOL % O_2	Probe Wash Volume = 100 ml				
VOL % CO					
VOL % N_2					

Vol % N_2 = (100% - % CO_2 - % O_2 - % CO)

OEHL FORM MAY 78 20

APPENDIX G

Laboratory Results

3305

AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910001 OEHL SAMPLE NO: 91041052

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910724 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L. Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

AL/OEBE
BROOKS AFB TX 78235-5000

AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910002 OEHL SAMPLE NO: 91041053

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910724 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

AL/OEBE
BROOKS AFB TX 78235-5000

PAGE 1

AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910003 OEHL SAMPLE NO: 91041054

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910724 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	81	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

AL/CEBE
BROOKS AFB TX 78235-5000

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AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910004 OEHL SAMPLE NO: 91041055

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910724 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

AL/OEBE
BROOKS AFB TX 78235-5000

AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910005 OEHL SAMPLE NO: 91041056

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910725 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L. Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

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BROOKS AFB TX 78235-5000

AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910006 OEHL SAMPLE NO: 91041057

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910725 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

AL/OEBE
BROOKS AFB TX 78235-5000

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AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910007 OEHL SAMPLE NO: 91041058

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910725 DATE REPORTED: 910813

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L. Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

SM-ALC/EMC
MCCLELLAN AFB CA 95652-5990

AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910008 OEHL SAMPLE NO: 91041059

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910725 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

AL/OEBE
BROOKS AFB TX 78235-5000

PAGE 1

AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910009 OEHL SAMPLE NO: 91041060

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910726 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

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BROOKS AFB TX 78235-5000

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AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910010 OEHL SAMPLE NO: 91041061

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910726 DATE REPORTED: 910813

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

SM-ALC/EMC
MCCLELLAN AFB CA 95652-5990

AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910011 OEHL SAMPLE NO: 91041062

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910726 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

AL/OEBE
BROOKS AFB TX 78235-5000

AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910012 OEHL SAMPLE NO: 91041063

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910726 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

AL/OEBE
BROOKS AFB TX 78235-5000

PAGE 1

AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910013 OEHL SAMPLE NO: 91041064

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910729 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

AL/OEBE
BROOKS AFB TX 78235-5000

AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910014 OEHL SAMPLE NO: 91041065

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910729 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

AL/OEBE
BROOKS AFB TX 78235-5000

AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910015 OEHL SAMPLE NO: 91041066

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910729 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

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BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910016 OEHL SAMPLE NO: 91041067

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910729 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L. Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

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REPORT OF ANALYSIS

BASE SAMPLE NO: CN910017 OEHL SAMPLE NO: 91041068

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910730 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

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REPORT OF ANALYSIS

BASE SAMPLE NO: CN910018 OEHL SAMPLE NO: 91041069

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910730 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

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REPORT OF ANALYSIS

BASE SAMPLE NO: CN910019 OEHL SAMPLE NO: 91041070

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910730 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

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REPORT OF ANALYSIS

BASE SAMPLE NO: CN910020 OEHL SAMPLE NO: 91041071

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910730 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

AL/OEBE
BROOKS AFB TX 78235-5000

AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH DIRECTORATE
BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910021 OEHL SAMPLE NO: 91041072

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910731 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	52	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L. Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

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BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910022 OEHL SAMPLE NO: 91041073

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910731 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

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REPORT OF ANALYSIS

BASE SAMPLE NO: CN910023 OEHL SAMPLE NO: 91041074

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910724 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	70	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

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BROOKS AFB TX 78235-5000

AIR FORCE
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BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910024 OEHL SAMPLE NO: 91041075

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910731 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by:

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by:

G. Cornell Long
Chief, Metals Analysis Function

TO:

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BROOKS AFB, TEXAS, 78235-5000

REPORT OF ANALYSIS

BASE SAMPLE NO: CN910025 OEHL SAMPLE NO: 91041076

SAMPLE TYPE: NON-POTABLE WATER

SITE IDENTIFIER: DATE RECEIVED: 910806

DATE COLLECTED: 910731 DATE REPORTED: 910813

SAMPLE SUBMITTED BY: SM-ALC/EMC

RESULTS

Test	Results	Units
Chromium	<50	ug/L
Chromium VI	<20.	ug/L

Comments:

< - Signifies none detected and the detection limits.

Analyzed by: Aaron L Forrest

Aaron L. Forrest, Sgt, USAF
Occupational Analysis Technician

Reviewed by: G. Cornell Long

G. Cornell Long
Chief, Metals Analysis Function

TO:

AL/OEBE
BROOKS AFB TX 78235-5000

APPENDIX H

Calibration Data

NOZZLE CALIBRATION DATA FORM

Date 29 July   Calibrated by Scott

Nozzle identification number	Nozzle Diameter[a]			ΔD,[b] mm (in.)	D_{avg}[c]
	D_1, mm (in.)	D_2, mm (in.)	D_3, mm (in.)		
29 July - Run 1 stack 1	0.310	0.310	0.311		0.310
30 July - Run 2 stack 1	0.312	0.312	0.311		0.311
31 July - Run 3 stack 1	0.312	0.311	0.310		0.311

where:

[a] $D_{1,2,3,}$ = three different nozzles diameters, mm (in.); each diameter must be within (0.025 mm) 0.001 in.

[b] ΔD = maximum difference between any two diameters, mm (in.), $\Delta D \leq$ (0.10 mm) 0.004 in.

[c] D_{avg} = average of D_1, D_2, and D_3.

[redacted] Stack 1

McClellan AFB

NOZZLE CALIBRATION DATA FORM

Date ______________ Calibrated by Scott

Nozzle identification number	Nozzle Diameter[a] D_1, mm (in.)	D_2, mm (in.)	D_3, mm (in.)	ΔD,[b] mm (in.)	D_{avg}[c]
24 July 91 – Run 1 stack #2	0.310	0.311	0.310		0.310
25 July 91 – Run 2 stack #2	0.310	0.308	0.309		0.309
26 July 91 – Run 3 stack #2	0.312	0.312	0.314		0.313

where:

[a] $D_{1,2,3,}$ = three different nozzles diameters, mm (in.); each diameter must be within (0.025 mm) 0.001 in.

[b] ΔD = maximum difference between any two diameters, mm (in.), $\Delta D \leq$ (0.10 mm) 0.004 in.

[c] D_{avg} = average of D_1, D_2, and D_3.

stack #2

McClellan AFB

Bldg 243 G

Post

METER BOX CALIBRATION DATA AND CALCULATION FORM

(English units)

Date 6 Nov 91 Meter box number 3

Barometric pressure, P_b = 29.313 in. Hg Calibrated by Vaughn / O'Brien

Orifice manometer setting (ΔH), in. H_2O	Gas volume: Wet test meter (V_w), ft^3	Gas volume: Dry gas meter (V_d), ft^3	Temperature: Wet test meter (t_w), °F	Temperature: Dry gas meter: Inlet (t_{d_i}), °F	Temperature: Dry gas meter: Outlet (t_{d_o}), °F	Temperature: Dry gas meter: Avg[a] (t_d), °F	Time (Θ), min	Y_i	$\Delta H@_i$ in. H_2O
0.5	5	5.015	69 71 70	70 74 72	68 70 69	70.5	12.88	0.997	1.90
1.0	5	5.013	72 73 72.5	77 81 79	71 73 72	75.5	9.079	1.001	1.888
1.5	10	10.042	75 74 74.5	8· 87 84.5	74 78 76	80.25	15.179	1.003	1.976
2.0	10	10.086	75 75 75	88 93 90.5	78 81 79.5	85.0	13.163	1.005	1.968
3.0	10	10.103	75 74 74.5	93 96 94.5	81 84 82.5	88.5	10.789	1.008	1.967
4.0	10	10.122	74 74 74	96 94 95	84 86 85	90	9.459	1.007	2.007
							Avg	1.004	1.951

ΔH, in. H_2O	$\frac{\Delta H}{13.6}$	$Y_i = \frac{V_w P_b (t_d + 460)}{V_d (P_b + \frac{\Delta H}{13.6}) (t_w + 460)}$	$\Delta H@_i = \frac{0.0317 \Delta H}{P_b (t_d + 460)} \left[\frac{(t_w + 460) \Theta}{V_w} \right]^2$
0.5	0.0368	$Y_i = \frac{(5)(29.313)(70.5+460)}{(5.015)(29.313+\frac{.5}{13.6})(70+460)}$	$\Delta H@_i = \frac{(0.0317)(.5)}{29.313(70.5+460)} \left[\frac{(70+460)(12.88)}{5} \right]^2$
1.0	0.0737	$Y_i = \frac{(5)(29.313)(75.5+460}{(5.013)(29.313+\frac{1.0}{13.6})(72.5+460)}$	$\Delta H@_i = \frac{(0.0317)(1.0)}{29.313(75.5+460)} \left[\frac{(72.5+460)(9.079)}{5} \right]^2$
1.5	0.110	$Y_i = \frac{(10)(29.313)(80.25+460)}{(10.042)(29.313+\frac{1.5}{13.6})(74.5+460)}$	$\Delta H@_i = \frac{0.0317(1.5)}{29.313(80.25+460)} \left[\frac{(74.5+460)(15.179)}{10} \right]^2$
2.0	0.147	$Y_i = \frac{(10)(29.313)(85+460)}{(10.086)(29.313+\frac{2.0}{13.6})(75+460)}$	$\Delta H@_i = \frac{0.0317(2.0)}{29.313(85+460)} \left[\frac{(75+460)(13.163)}{10} \right]^2$
3.0	0.221	$Y_i = \frac{(10)(29.313)([illegible]+460)}{(10.103)(29.313+\frac{3.0}{13.6})(74.5+460)}$	$\Delta H@_i = \frac{0.0317(3.0)}{29.313(88.5+460)} \left[\frac{(74.5+460)(10.789)}{10} \right]^2$
4.0	0.294	$Y_i = \frac{(10)(29.313)(90+460)}{(10.122)(29.313+\frac{4.0}{13.6})(74+460)}$	$\Delta H@_i = \frac{0.0317(4.0)}{29.313(90+460)} \left[\frac{(74+460)(9.459)}{10} \right]^2$

[a] If there is only one thermometer on the dry gas meter, record the temperature under t_d.

METER BOX CALIBRATION DATA AND CALCULATION FORM

(English units) Pre

Date 20 Sept 90 Meter box number Nutech #3

Barometric pressure, P_b = 29.23 in. Hg Calibrated by Vaughn / O'Brien

Orifice manometer setting (ΔH), in. H_2O	Gas volume: Wet test meter (V_w), ft^3	Gas volume: Dry gas meter (V_d), ft^3	Temperature: Wet test meter (t_w), °F	Temperature: Dry gas meter Inlet (t_{d_i}), °F	Temperature: Dry gas meter Outlet (t_{d_o}), °F	Temperature: Dry gas meter Avg[a] (t_d), °F	Time (Θ), min	Y_i	$\Delta H@_i$ in. H_2O
0.5	5	4.97	81 84 542.5	81 85	80 81	541.75	13.66	1.0034	2.1987
1.0	5	4.95	83 81 542	86 90	81 83	545	9.32	1.0131	2.0311
1.5	10	9.98	80 80 540	91 90	83 84	547	15.16	1.0112	1.9931
2.0	10	9.99	80 79 539.5	91 92	84 85	548	13.11	1.0117	1.9800
3.0	10	9.98	79 79 539.0	93 94	85 85	549.25	10.67	1.0134	1.9592
4.0	10	9.88	79 79 539.0	95 96	85 86	550.5	9.24	1.0234	1.9546
							Avg	1.0127	2.0195

$Y \pm .05$

ΔH, in. H_2O	$\frac{\Delta H}{13.6}$	$Y_i = \frac{V_w P_b (t_d + 460)}{V_d \left(P_b + \frac{\Delta H}{13.6}\right)(t_w + 460)}$	$\Delta H@_i = \frac{0.0317\ \Delta H}{P_b\ (t_d + 460)} \left[\frac{(t_w + 460)\ \Theta}{V_w}\right]^2$
0.5	0.0368	$Y_i = \frac{5\,(29.23)\,(541.75)}{4.97\,(29.23 + 0.5/13.6)\,542.5}$	$\Delta H@_i = \frac{0.0317\,(0.5)}{29.23\,(541.75)} \left[\frac{(542.5)(13.66)}{5}\right]^2$
1.0	0.0737	$Y_i = \frac{5\,(29.23)\,(545)}{4.95\,(29.23 + 1.0/13.6)\,542}$	$\Delta H@_i = \frac{0.0317\,(1.0)}{29.23\,(545)} \left[\frac{(542)(9.32)}{5}\right]^2$
1.5	0.110	$Y_i = \frac{10\,(29.23)\,(547)}{9.98\,(29.23 + 1.5/13.6)\,540}$	$\Delta H@_i = \frac{0.0317\,(1.5)}{29.23\,(547)} \left[\frac{(540)(15.16)}{10}\right]^2$
2.0	0.147	$Y_i = \frac{10\,(29.23)\,(548)}{9.99\,(29.23 + 2.0/13.6)\,539.5}$	$\Delta H@_i = \frac{0.0317\,(2.0)}{(29.23)\,(548)} \left[\frac{(539.5)(13.11)}{10}\right]^2$
3.0	0.221	$Y_i = \frac{10\,(29.23)(549.25)}{9.98\,(29.23 + 3.0/13.6)\,539}$	$\Delta H@_i = \frac{0.0317\,(3.0)}{(29.23)\,(549.25)} \left[\frac{(539)(10.67)}{10}\right]^2$
4.0	0.294	$Y_i = \frac{10\,(29.23)\,(550.5)}{9.88\,(29.23 + 4.0/13.6)\,539}$	$\Delta H@_i = \frac{0.0317\,(4.0)}{(29.23)\,(550.5)} \left[\frac{(539)(9.24)}{10}\right]^2$

[a] If there is only one thermometer on the dry gas meter, record the temperature under t_d.